SmartState™

SC Centers of Economic Excellence

2011-2012 Annual Report to the S.C. General Assembly and the S.C. Budget & Control Board

2011-2012 SmartState Program Annual Report

FRONT COVER: (LEFT) MUSC SMARTSTATE ENDOWED CHAIR IN CHEMICAL BIOLOGY MEDICINAL CHEMISTRY, DR. PATRICK WOSTER, CHECKS THE PRESSURE ON A VACUUM DISTILLATION APPARATUS. (UPPER RIGHT) BMW ENDOWED CHAIR IN AUTOMOTIVE SYSTEMS INTEGRATION, DR. PAUL VENHOVENS, WORKS WITH STUDENTS IN THE CLEMSON UNIVERSITY INTERNATIONAL CENTER FOR AUTOMOTIVE RESEARCH (CU-ICAR) LAB. (BOTTOM RIGHT) DR. KENNETH REIFSNIDER, USC SMARTSTATE ENDOWED CHAIR IN SOLID OXIDE FUEL CELL RESEARCH AND MEMBER OF THE NATIONAL ACADEMY OF ENGINEERING, IS BRIEFED ON RESEARCH RESULTS BY DR. FRANK CHEN.

In December 2011, the SmartState Program™ hosted its first national conference in Charleston. The conference drew industry, government and academic leaders from around the United States and world to see firsthand how South Carolina has developed its knowledge-based economy over the past decade through advanced research centers at the state's three research institutions: Clemson University, Medical University of South Carolina, and University of South Carolina. SmartState researchers from all 48 Centers of Economic Excellence were present to showcase their achievements. Invited lecturers from prestigious entities such as the U.S. Navy, the Federal Reserve, the U.S. Department of Commerce, Harvard University, and the Governments of Australia and Israel, to name but a few, were extremely impressed with the success of the SmartState Program in such a short time.

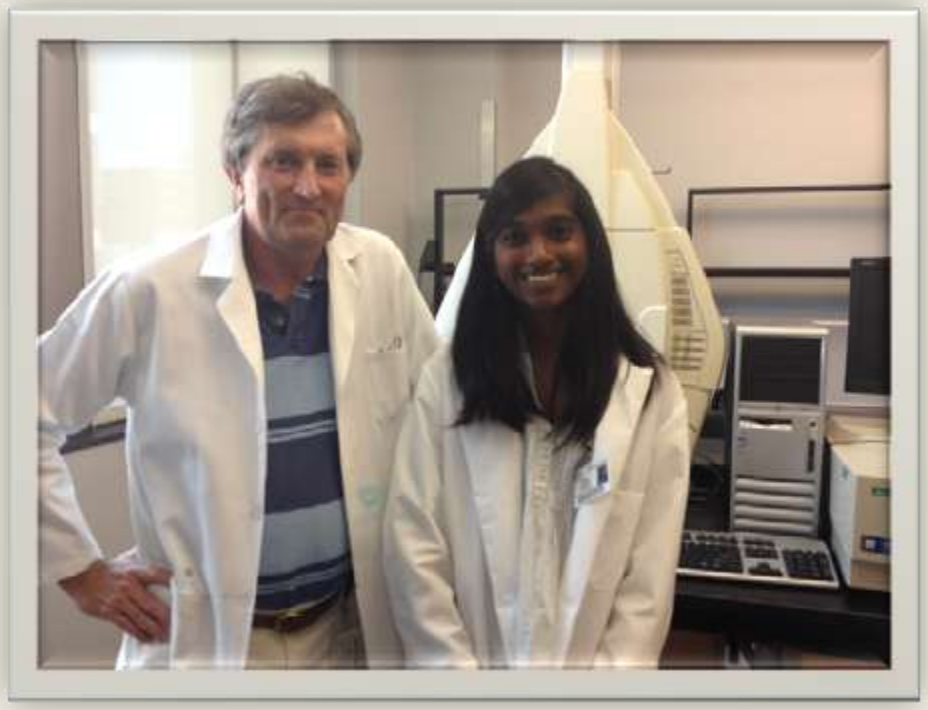
What began as a vision by the General Assembly ten years ago following trips by business and political leaders to academic research campuses in Texas and North Carolina has now burgeoned into reality: the reinvention of the state economy by increasing our knowledge base. To date, 42 world-class researchers known as SmartState Endowed Chairs, plus their research teams, are working around-the-clock to create economic opportunities for South Carolinians. **The results are phenomenal: $1.4 billion in investment in the state's economy, plus the creation of 8,000-plus jobs.** In addition, the program is responsible for the creation of 22 startup companies and the construction of R&D facilities and factories for companies like Timken, Sage Automotive Interiors, and Proterra.

The SmartState Program is a brightening star on the global economic map. In November 2011, the CBS Evening News profiled the program for drawing electric bus manufacturer Proterra to the Upstate. In FY 2012, the SmartState Program was nominated for the prestigious Harvard Innovations in American Government Award. And just a few years ago, the Advisory Group at Huron called the program the leading academic challenge grant program in the nation, adding that the program should be the envy of all other states.

Despite these and other accomplishments, the SmartState Program is at a crossroads. Although the program has fulfilled its mandate to secure matching funds for all 48 Centers—and in fact has exceeded that mandate by securing hundreds of millions of dollars more in external investment—the program has not received new annual funding since FY 2008. By the end of FY 2013, the program will run out of funding for future research center awards and will only have a small amount of funding left to operate the program through FY 2016.

I firmly believe that the SmartState Program has greatly improved our state's standing in the global economy and that we can improve our competitive position in the global market even further. This year, the SmartState Review Board worked with the South Carolina Secretary of Commerce to understand better what companies want in terms of partnerships with academic research institutions. The innovative program improvements the Review Board plans to implement in 2013, along with resumed funding from the General Assembly, will continue to inspire innovative businesses to relocate in South Carolina.

Regan Voit
Chair, SmartState Review Board
November 2012



SmartState Endowed Chair Dr. Kenneth Tew (left) with SC Governor's School of Science and Mathematics (GSSM) rising senior Ashani Ranwala. Ranwala participated in the SmartState Program/GSSM summer internship program in June 2012, learning the basics of cancer research in Dr. Tew's research laboratory at MUSC.

When I moved from the Fox Chase Cancer Center in 2004, I left an endowed chair in Philadelphia to become the first SmartState Endowed Chair. Eight years on, I can reflect upon the successes that have accompanied the journey.

Scientists train to think laterally and discover things that others have not. In reality, today's environment requires academic investigators to become "individual small businesses." We attract financial support so that our ideas might be studied. In eight years at MUSC, I have been the recipient of grants and contracts from government and private pharmaceutical sources in excess of $15 million. These grants have bolstered the South Carolina economy and provided high-tech job opportunities. One of the most recent grants, a Center of Biomedical Research Excellence award, totals almost $11 million and has resulted in the creation of the "Redox and Cell Signaling" Center at MUSC.

Funds from our Center have been used to recruit outstanding investigators and have helped build a vibrant Pharmacology Department at MUSC. In addition, interactions with colleagues in the pharmaceutical and biotech sector have led to the clinical testing of three new anticancer drugs. Such efforts exemplify the principles underlying translational research and have helped place MUSC in a position of international prominence—a fact perhaps best represented by the National Cancer Institute's 2009 recognition of the Hollings Cancer Center as a National Cancer Center.

I am now one of 42 SmartState Endowed Chairs. The SmartState Program has provided opportunities for me to interact with exceptional fellow researchers. The program has advanced the economy and reputation of South Carolina in a manner that few states can claim. In the late 14th century, the Medici Family of Florence fostered the Italian Renaissance with philanthropic support of the arts and sciences; it is sustaining to know that this spirit of support exists today—and after all, there is a Florence in South Carolina.

Dr. Kenneth Tew
Incoming Chair, SmartState Council of Chairs
John C. West Chair in Cancer Research, Translational Cancer Therapeutics Center of Economic Excellence
November 2012

"A flower waiting to bloom" was the conclusion of a consultant report produced several years ago in reference to the South Carolina tourism industry. As I read this report on my way to Columbia from the Canadian Rockies in December 2009, I began planning how my Center could help that flower flourish. My SmartState mission from the beginning has been to lead cutting-edge tourism and hospitality research that would be relevant and directly applicable to the tourism industry in South Carolina.

A good example is a recent study we directed in Aiken where our Center was asked to conduct a feasibility study for a $130 million International Equestrian Center. If development moves ahead, the project will have a significant impact on the economy and local job creation and will raise the profile of our state internationally.

Our SmartState Center has also worked closely with industry stakeholders in the Pee Dee region to develop tourism. We discovered from our research that many rural areas of South Carolina have the potential to attract tourists, but they have little brand recognition, both among tourists and South Carolina residents. There is a need for improved relationships between tourism stakeholders in the region, and between tourism stakeholders in the Pee Dee and the coastal regions.

Dr. Hudson lectures in the USC College of Hospitality, Retail and Sport Management.

In another exciting initiative, we received funding to develop a medical tourism strategy for South Carolina. There are a growing number of patients who travel for medical care, and South Carolina can capitalize on this trend. At the moment, only two percent of people receiving medical services in South Carolina are non-residents, but their expenditures exceed $700 million. In addition to my Center's research, I believed we could do more to create new jobs, and thus have created a tourism and hospitality business incubator; the new incubator will offer opportunities for tourism and hospitality entrepreneurs to turn their business ideas into a reality.

Since arriving in South Carolina, I have made over a dozen keynote speeches and published a number of industry articles. I am also invited regularly to comment on various local TV channels and in national newspapers. As awareness of our Center's activities grows, so too does awareness of the SmartState program. It was an honor to be part of the first SmartState National Conference in Charleston last December. And introducing our first SmartState Endowed Chair, cancer researcher Dr. Igor Roninson, at the Science Café series in September (in Five Points, Columbia) made me realize what tremendous talent has been attracted to the state due to this program.

Three years is not enough time for the flowering process of South Carolina's tourism to be complete, but the industry is being nurtured, fertilized, and is propagating due to these new and innovative tourism projects.

Dr. Simon Hudson
Chair, SmartState Council of Chairs
SmartState Endowed Chair, Tourism & Economic Development Center of Economic Excellence
November 2012

MESSAGE FROM SMARTSTATE INVESTOR DIALYSIS CLINICS, INC.

Dialysis Clinics, Inc. (DCI) is the largest not-for-profit dialysis provider in the U.S. Our corporate philosophy is to provide excellent and comprehensive patient care as well as to support research which will benefit future patients with kidney disease. DCI clinics consistently provide care to patients with end-stage kidney disease which is rated higher than facilities run by for-profit corporations. DCI also has a rich tradition of supporting research. We have given over $188 million to research initiatives nationally. DCI and the Medical University of South Carolina Nephrology Division have a longstanding relationship which has enabled the delivery of excellent patient care in the six DCI outpatient dialysis units directed by MUSC faculty. Prior to the creation of the Renal Disease Biomarkers SmartState Center of Economic Excellence, DCI had provided funds to MUSC to support three endowed chairs in nephrology. In addition, DCI funds were used to initiate the renal biomarker program at MUSC in 2001. When the SmartState application for the Renal Disease Biomarkers Center was submitted in 2008, the initial program which was started with support from DCI had grown into a comprehensive biomarker discovery program supported by Federal grants from the National Institutes of Health and the U.S. Department of Veterans Affairs.

Through the SmartState Program, DCI saw the opportunity to enhance its impact on high-quality kidney research at MUSC by contributing funds which would be matched by the State of South Carolina. The program fit well with our corporate philosophy of improving the lives of patients with kidney disease while being conscientious stewards of the funds used to support research. Initially, DCI contributed $1.1 million to the Center. In 2010, DCI made a further large contribution to enable the purchase of a state-of-the-art mass spectrometer, which has significantly enhanced research at the Center. The mass spectrometer generated data that demonstrated for the first time that a hormone system called the renin angiotensin system is involved in acute kidney injury. This discovery will likely lead to the identifications of new ways to diagnose and treat kidney disease.

DCI is proud of the support we have provided to research initiatives and continues to be committed to reducing the large burden of illness and death caused by kidney disease. The Renal Disease Biomarkers SmartState Center of Economic Excellence has provided an excellent avenue to magnify the effects of our investment and contributions.

DCI has invested $3.4 million in the SmartState Program, with contributions to fund critical research at the Renal Disease Biomarker Center of Economic Excellence at MUSC. This Center is currently focused on identifying biomarkers that identify or predict prognosis for acute kidney injury and diseases. In FY 2012, the Center filed two provisional patent applications for the discovery of kidney disease biomarkers.

top photo: Dr. Mike Janech extracts proteins from the urine of a patient with focal segmental glomerulosclerosis.

bottom photo: Drs. Arthur and Janech analyze biomarker data using a mass spectrometer.

Dialysis Clinics, Inc. (opposite page) is one of dozens of major corporations, foundations, and organizations which has invested in the South Carolina knowledge-based economy through the SmartState Program. **More than 40 organizations have made investments of $500,000 or more in the SmartState Program for a total of $111 million.** Examples of major investment contributors include BMW, which has invested $11 million, and The Duke Endowment and Health Sciences South Carolina, which combined have invested nearly $30 million. Below is a select list of corporate and organizational investors of $500,000 or more.

SmartState Program Corporate & Organizational Investors of $500,000 or Greater

Abney Foundation
BASF
BlueCross BlueShield Foundation of SC
Comporium Group
Dialysis Clinics, Inc.
Duke Energy Foundation
Fluor Corporation
General Atomics
GlaxoSmithKline
Health Sciences South Carolina
Kellogg Foundation
Michelin
PalmettoNet
Research to Prevent Blindness
Samuel Freeman/ Donaldson Charitable Trust
Smith & Nephew
The Spaulding Paolozzi Foundation
Toyota
Bank of America Foundation
Biomass Gas & Electric
BMW
Daniel Island Company
The Duke Endowment
Electric Cooperatives of SC
Force Protection Industries
George B. Sibert Annuity
Greenville Hospital System
J.E. Sirrine Textile Foundation
Kentwool
Okuma
Palmetto Health
Robert Wood Johnson Foundation
Santee Cooper
Spartanburg Regional Healthcare System
Timken
Westinghouse

HOW THE SMARTSTATE PROGRAM WORKS

In 2002, the South Carolina General Assembly passed the Research Centers of Economic Excellence (RCEE) Act. From 2003 to 2008, $180M was appropriated from the SC Education Lottery to establish unique Centers of Economic Excellence at the state's three research institutions: Clemson, USC, and MUSC.

The RCEE Act created the SmartState Review Board, which provides program oversight. Staff and operational support are provided by the South Carolina Commission on Higher Education.

The SmartState Review Board oversees an annual competitive process whereby Centers of Economic Excellence and supporting SmartState Endowed Chairs are proposed by the research institutions. Once a Center is awarded, an institution has 18 months to acquire $1:$1 matching pledges from non-state sources equal to the state award ($2M-$5M). Pledges must be "realized" (in hand) within six-and-a-half years of the award date. The entire state award plus a portion of the $1:$1 match is placed into permanent endowment at the institution that serves as Center fiscal agent; the endowment provides funding for Center research equipment, lab construction, and research team salaries.

The Review Board has awarded 48 Centers and 86 SmartState Endowed Chair positions. Each Center specializes in knowledge-based research fields such as engineering, nanotechnology, biomedicine, cancer research, and energy science. The SmartState Endowed Chairs secure private sector and federal grants to increase the state's knowledge base and stimulate the economy.

left to right: **The Honorable Dr. Peter D. Beattie along with USC President Harris Pastides and SmartState Review Board member Bobby Pearce.**

left to right: **USC Senior Vice Provost Dr. Christine Curtis, SmartState Review Board member Pat Wilson, and SmartState Endowed Chair Dr. Louis Guillette.**

THE SMARTSTATE PROGRAM BY THE NUMBERS

The SmartState Program has a unique "Challenge Grant" financial model. [See previous page.]

- **$191.6M has been awarded to create 48 Centers of Economic Excellence. Source of award funding:**
  - $180M, State Education Lottery Appropriations
  - $11.6M, Endowment Accrued Interest
- **$191.6M Non-State Match Investment Requirement:**
  - $188.9M in ***non-state match*** investments have been pledged **(99% of all required matches)**.
  - $174.9M of these pledges have been paid **(91.3%)**.
  - **26 corporations** have made ***non-state match*** investments of **$500K or more**, for a total of **$55M**. This includes companies such as BMW, Michelin, Timken, Smith & Nephew, General Atomics, Westinghouse, Fluor, and many others.
  - **17 foundations** and non-profit organizations have made ***non-state match*** investments of **$500K or more**, for a total of **$55.6M**. This includes organizations such as BlueCross BlueShield of SC Foundation, the Duke Endowment, Health Sciences South Carolina, Kellogg Foundations, and others.
  - The remaining $78.3M in non-state match investments derive from corporate matches of less than $500K, federal grants, and private philanthropy.
  - Federal grants account for less than 20% of the non-state match total.

SmartState State Funding

TOTAL STATE FUNDING = $209.2M
$180M, State Lottery Appropriations
$29.2M, Endowment Accrued Interest

$191.6M	Awards for 48 Centers
6.0M	2013 RFP to issue new awards
3.0M	Reserved for SmartState "Commerce" Awards *
5.9M	Operating Expenses FY2003-13
$206.5M	TOTAL
$ 2.7M	REMAINDER

* In 2010, the RCEE Act was amended to create a new type of award in conjunction with the SC Department of Commerce. In FY 2010, an RFP was issued for these awards for which $3.0M is available.

The SmartState Program has not received annual funding since 2008.

Without new funds, the program will not have funds for new Center awards by the end of FY 2013.

SmartState™
SC Centers of Economic Excellence

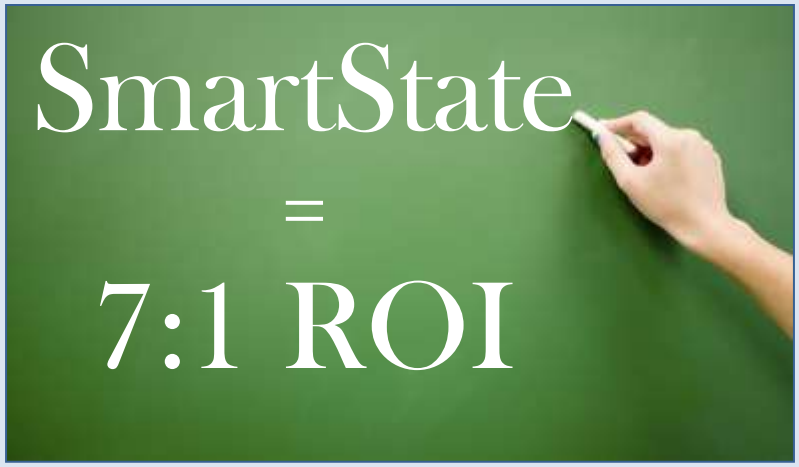
STATE INVESTMENT
(2003-2012)
$180 million

EXTERNAL INVESTMENT

$1.4 BILLION

QUESTION:

Is the SmartState Program fulfilling its mandate to build the knowledge-based economy in South Carolina?



ANSWER: YES!

For every $1 SC government has invested in academic research . . .

the private sector and non-state sources have invested $7!

QUESTION: What are the sources of the $1.4 BILLION in external investment in SmartState?

ANSWER:

NON-STATE MATCHING FUNDS: $191.6 MILLION

State dollars must be matched on $1:$1 basis with investment from non-state sources such as corporations, non-profit organizations, and private investors. Federal funds count for less than 20% of non-state matching funds.

RESEARCH GRANTS: $408.4 MILLION

The SmartState Endowed Chairs and their research teams receive corporate and federal grants to conduct their innovative research. In FY2012 alone, $70.3M in SmartState research team grants entered the South Carolina economy.

CORPORATE INFRASTRUCTURE INVESTMENT: $529.8 MILLION

Companies like American Titanium Works, Proterra, and Trulite have relocated manufacturing and research facilities in South Carolina to be near SmartState research teams. In addition, other state-based companies have expanded existing facilities in order to accommodate industry collaborations with the Centers of Economic Excellence.

COMMITTED GRANTS & PLEDGES: $307.5 MILLION

Additional non-state matching pledges and committed research grants from program investors.

The impact of the SmartState Program is akin to a train picking up speed down a track. From 2008 to 2012, there was an exponential impact of SmartState research on the South Carolina economy, which will continue increasing as more SmartState Endowed Chairs are hired.

QUESTION: How many jobs has the SmartState Program created?

ANSWER: SmartState has created more than 8,000 new jobs in South Carolina!

The SmartState Program is charged with the creation of high-paying jobs in South Carolina. To date, the SmartState Program has created **8,078 high-paying, knowledge-based economy jobs**. This figure includes 422 SmartState personnel, 32 start-up company employees, and 1,159 corporate relocation personnel. According to the USC Darla Moore School of Business, an additional 6,465 new jobs have likely resulted from the impact of more than $400 million in extramural research funding brought into the South Carolina economy by SmartState Endowed Chairs and their research teams. This includes vital construction jobs as seen in the photo below.

Concrete pour for the Restoration Institute Wind Turbine Test Facility being developed on the Restoration Institute campus in North Charleston. The facility will be instrumental in testing wind turbine technologies to supply alternative energy to support urban growth. This is relevant to research at the Urban Ecology & Restoration Center of Economic Excellence.

SMARTSTATE JOBS CREATION BY SECTOR *

Automotive Industry: 1,075
Energy & Biomedicine Industry: 84
Research Institutions: 422
SmartState Startup Companies: 32

* Additionally, 6,465 jobs estimated across sectors.

QUESTION: Are these 8,000-plus SmartState jobs really high-paying?

ANSWER: YES! The average salary of a SmartState job is just under $77,000!* That's nearly twice the average SC annual salary!

* Data reflects reported salaries of 439 SmartState jobs.

QUESTION: Aren't the 422 university jobs just funded with taxes and tuition?

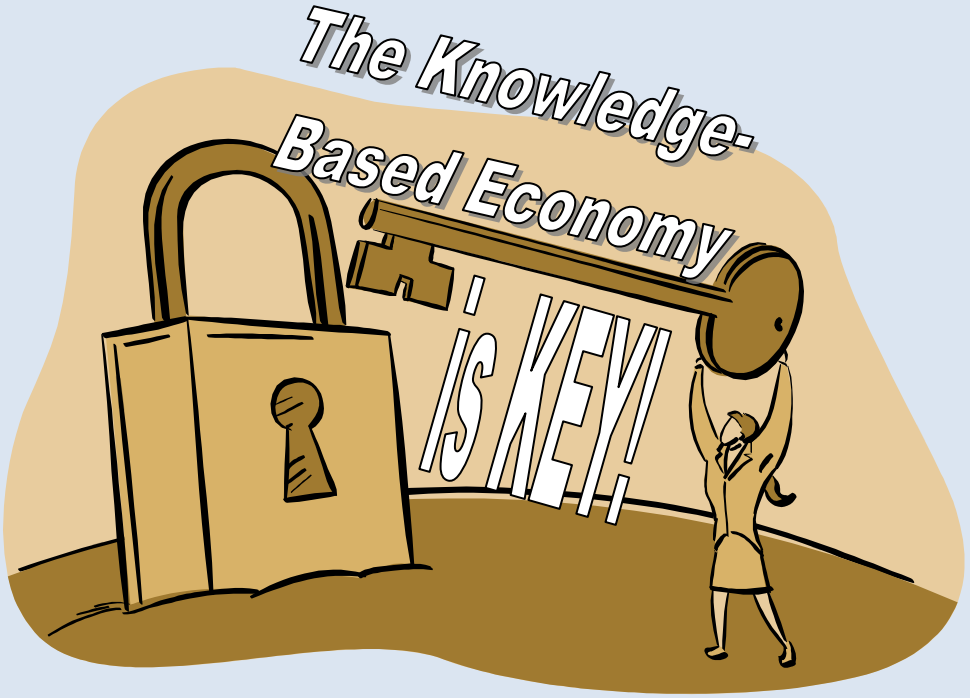
ANSWER: No. Leading researchers typically secure between 25%-50% of salary compensation from competitive extramural grants.

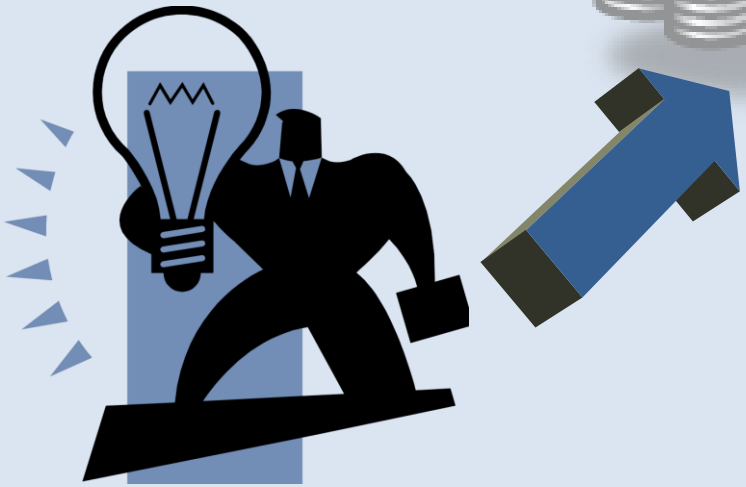
QUESTION: What is the economic impact of graduate students who enter the state to study with SmartState Endowed Chairs?

ANSWER: Graduate students who remain in SC post-degree have a sizeable impact of $4.2 million annually on local economies.

Ph.D. student Jessica Frankel discusses a laboratory experiment with SmartState Endowed Chair Dr. Brian Benicewicz.

Charleston businesswoman Anita Zucker speaks with Clemson President Jim Barker following the announcement that the Zucker Family is donating $5 million for the construction of a graduate education center at the former North Charleston naval base.





QUESTION:

What is Technology Transfer?

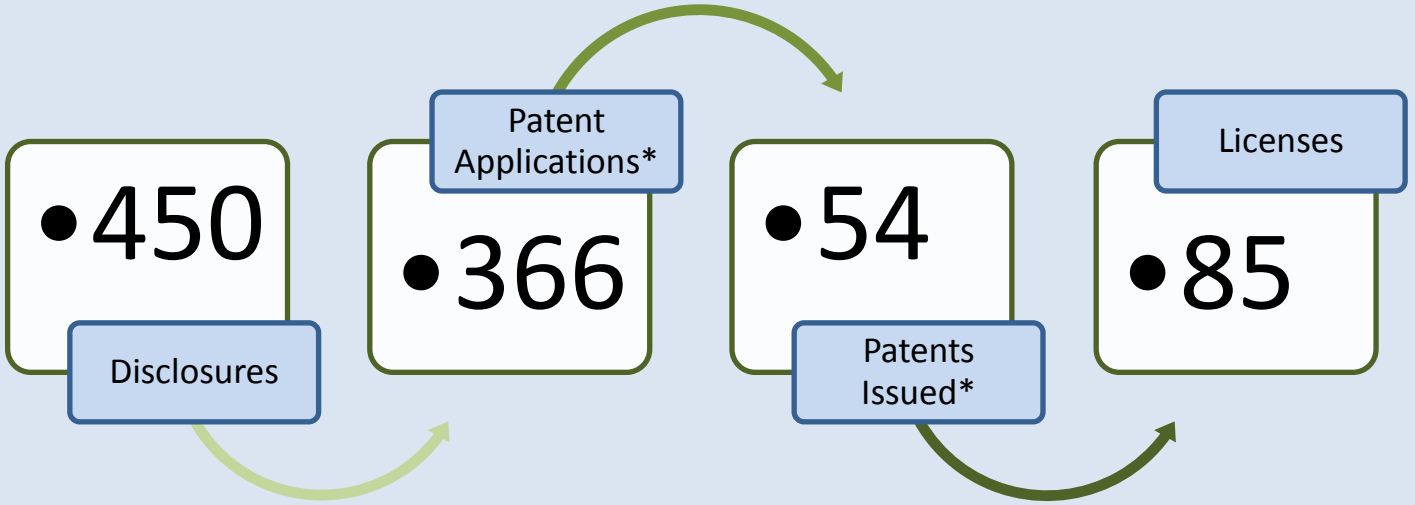
ANSWER:

TECHNOLOGY TRANSFER is the process of converting scientific discoveries into marketable products. When a researcher makes a scientific **DISCLOSURE** (or discovery) that has commercial possibilities, his or her institution files for a **PATENT**—a set of exclusive rights granted by the U.S. Government to an inventor (or assignee) for a certain period of time. USC, MUSC, and Clemson have technology transfer offices to handle the patent process of scientific discoveries (also called "intellectual property").

A patent allows an invention owner to bring a product to market exclusively. Often with high-tech products, this "exclusivity" provides enough financial return to justify the investment required to place a product on the market. In addition to U.S. patents, institutions seek international patents that secure invention rights abroad.

With a **LICENSE**, a university grants the right to practice the patentable invention to a commercial entity, which then invests the resources required to place a product on the market. There are typically two ways that technology transfer leads to economic development:

SMARTSTATE PROGRAM TECHNOLOGY TRANSFER STATISTICS



* Includes U.S. and International.

Sometimes the entity that purchases a license starts a new company based on the newly developed product or service. This commercial enterprise is called a **STARTUP COMPANY**. Other times, an existing company will license the intellectual property and produce the new product or service, which leads to a robust relationship with the university and region.

Selling licenses for the use of intellectual property can bring economic success. The licensure of inventions such as Gatorade and Taxol has netted Florida institutions of higher education hundreds of millions of dollars.

While the SmartState Program is relatively young in terms of intellectual property generation, USC, MUSC, and Clemson have received more than $900,000 in license income to date. Currently, SmartState researchers are working to develop and commercialize products, including robotic bio-printers, treatments for macular degeneration, topical hydrogel treatment for acute spinal cord injuries, and therapeutic agents for Parkinson's disease.

For non-biomedical and engineering scientific disclosures, the development timeline from the "Eureka!" moment in the research laboratory to placement of a product on a marketplace shelf is generally five to ten years. However, the commercialization of biomedical disclosures takes much longer, sometimes 15 to 20 years, as biologics and drugs require on average six to seven years of FDA regulatory trials alone.

FirstString Research, associated with the Regenerative Medicine Center of Economic Excellence, is a Charleston startup company focused on regenerative medicine applied to wound healing. The company is con-ducting clinical trials in Europe on its first scar prevention topical gel.

SmartState Endowed Chair Dr. John Schaefer of the Clinical Effectiveness and Patient Safety Center is the founder of SimTunes LLC. SimTunes produces health care simulation educational materials and has a venture agreement with Laerdal and Health Stream Corp.

When USC SmartState Endowed Chair Dr. Igor Roninson *(second from right)* was appointed to the Translational Cancer Therapeutics Center, he relocated his biomedical company Senex to South Carolina, along with a team of 12 researchers and their families.

trulite
Clean, reliable power – anywhere.

Four years ago, clean tech power products company Trulite relocated to Columbia to work with USC and the Hydrogen Economy SmartState Center. Now Trulite is relocating its California Advanced Engineering Group to Columbia and will take residence at USC Innovista. "The location, entrepreneurship, as well as cutting-edge research in state-of-the-art labs at USC, make this a perfect decision for Trulite at this stage of our growth and development," says Ronald Seftick, President & CEO of Trulite. Trulite develops and manufactures alternative or "green" energy using fuel cells and proprietary Hydrocell fueling technology. Trulite's range of portable fuel cells create "hydrogen on demand" through a proprietary and patented chemical processes that operates at very low temperature and pressure.

SMARTSTATE PROGRAM STARTUP COMPANIES

Advanced Photonic Crystals
FibroTherapeutics, Inc.
FirstString Research
Hydrogen Hybrid Mobility
ImmoMod, Inc.
Palmetto Fuel Cell Technologies, LLC
MagAssemble LLC
MicroVide
MitoChem Therapeutics, LLC
MitoHealth, Inc.
NextGenEn, Inc.
NXT
Parallel Permeation, Inc.
Protara
Regal Solutions, LLC *
SC Science Solutions, LLC
SchnellGen, Inc.
SemiAlloGen, Inc.
SimTunes, LLC
Specialty Custom Fibers
Tetramer Technologies
Vortex Biotechnology

*** In FY 2012, USC appointed Dr. John Regalbuto as SmartState Endowed Chair for the Catalysis for Renewable Fuels Center of Economic Excellence. His startup company, Regal Solutions, LLC, already has one invention disclosure, for which it has applied for a patent.**

SMARTSTATE CORPORATE RELOCATIONS

American Titanium Works
BMW ITRC
CADFEM U.S. *
Cephos
Clean Energy
Cooliemon Technologies *
Dreamweaver *
Fields Group, LLC
Focus Chemicals *
Greenway Energy
Innoventure *
Intec U.S. Inc.
JTEKT TC
Mallet Technology *
Mumford Industries *
Proterra (See profile on page 27.)
Sage Automotive Interiors *
Senex Biotechnology
Simpack, Inc.
ThermoPur Technologies *
Trulite

*** In May 2012, CU-ICAR opened the doors to the Center for Emerging Technologies (CET) facility, its first multi-tenant building. CET provides office, administrative, and laboratory space for the transportation, technology, and energy sectors, including companies like Sage Automotive Interiors and others footnoted above. These companies have positioned themselves on the CU-ICAR campus to be close to the four SmartState Endowed Chairs and their research teams.**

Consul General of Israel to the Southeast Opher Aviram takes a test drive in the DriveSafety CDS-250 Simulator. The CDS-250 is part of the research being conducting at the SeniorSMART Center of Economic Excellence, a collaboration between USC and Clemson University.

Speaker of the House Bobby Harrell accepts a plaque recognizing his championship of the SmartState Program and advocacy of knowledge-based economic development in the state.

South Carolina Commerce Secretary Bobby Hitt delivers a presentation on corporate investment at the state's senior research institutions.

SmartState researcher Dr. Gene Eidson discusses the Intelligent River™ project.

SC Rep. Rita Allison and former Queensland (AU) Premier Dr. Peter Beattie (*left*) discuss the success of Israeli tech companies with keynote speaker Saul Singer.

The Inaugural SmartState Program National Conference

In December 2011, the SmartState Review Board and the SmartState Council of Chairs hosted the inaugural SmartState Program National Conference in Charleston. The National Conference was an international showcase of knowledge-based economic development success in South Carolina through the SmartState Program and the 48 Centers of Economic Excellence at the state's three senior research institutions. Several hundred global leaders from industry, academia and government gathered to meet and listen to the SmartState Endowed Chairs and their research teams.

SmartState Endowed Chairs, SmartState Review Board members, and other guests at the inaugural 2011 SmartState National Conference in Charleston.

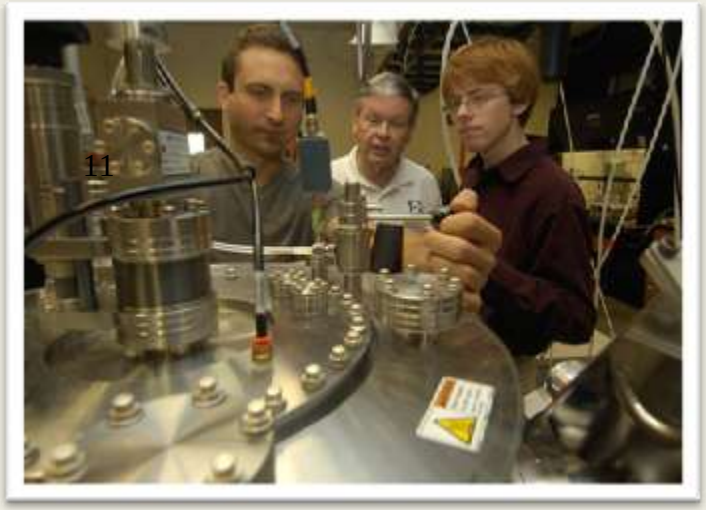
The list of participating organizations and entities included U.S. Department of Commerce, Federal Reserve, General Electric, U.S. Navy, Michelin, Governments of Israel and Australia, AT&T, South Carolina Department of Commerce, Harvard University, American Association for the Advancement of Science, National Center for Manufacturing Sciences, University of Kansas, Association of University Technology Managers, among others.

The SmartState Program National Conference provided a unique opportunity for South Carolina leaders and the state's leading scientists and engineers to present firsthand the numerous successes of SmartState research centers in such critical industrial fields as automotive engineering, biomedicine, advanced materials, and environmental science.

SC businesswoman and SmartState investor Ms. Anita Zucker praises "the South Carolina Research Triangle" of Clemson, USC, and MUSC.

As a result of the event, South Carolina is becoming increasingly regarded as a serious contender in the global economy, as a place where businesses want to relocate, and where the world's leading minds are considering conducting their unique work and commercialization efforts.

South Carolina's Best and Brightest High School Students Study Alongside SmartState Endowed Chairs



left to right: **Dr. Christopher Metting of USC, GSSM President Dr. Murray Brockman, and GSSM rising senior Brian Hurst work on a sputtering chamber in Dr. Lauterbach's research lab.**

SmartState Endowed Chair Dr. Jochen Lauterbach and Hurst.

My Summer in Dr. Lauterbach's SmartState Lab
by GSSM Rising Senior Brian Hurst

For my summer research project, I worked at the University of South Carolina under the guidance of Dr. Jochen Lauterbach. During my research internship, a sputtering chamber, which is a device that knocks loose pieces of a metal disk and deposits them onto a substrate, was used mostly to place different oxide layers onto a layer of silicon. My research project entailed creating a device called an ellipsometer to measure the thickness of the deposited layers formed by the sputtering chamber.

I learned more than I thought possible about optics in only six weeks in Dr. Lauterbach's lab. However, despite my focus on the physical construction of the ellipsometer, learning how to do the research was the most important part of what I did.

Working with Dr. Lauterbach in his lab, I got a glimpse into what really happens in research. I learned that research is an extension of real life, not some happy, carefree place where people in white lab coats sit around and swirl flasks. In real-life research, problems come up—like supplies not arriving on time, or not having important parts needed. Then there are times when you have the needed parts, but they don't work.

I also learned that research is about more than trying to answer some big question; research is about trying to find creative solutions to solve the bigger problem. What a person learns while answering the question is as important, if not more so, than the original question itself.

My experience with Dr. Lauterbach and his lab group taught me so much!

My Summer in Dr. Tew's SmartState Lab
by GSSM Rising Senior Ashani Ranwala

Working this summer as a research intern at MUSC under the supervision of Dr. Tew was a great experience. I learned to apply concepts I had learned in the classroom in a lab setting.

At the Governor's School, science classes have both laboratory and lecture aspects, but by working in a lab, I was excited to gain real-world experience. I am interested in a career in oncology, but I wasn't sure whether I wanted to focus on the clinical or research side. The experience with Dr. Tew gave me the chance to dabble in the research side, and I learned how time-intensive and orderly a researcher must be in order to preserve the accuracy and safety of experiments. I also learned how to use a variety of scientific equipment and the science behind them, which helped me understand the concepts behind my research tests.

My research dealt with the effects of hydrogen peroxide mouthwash on proteins and genes in the buccal cells, and I studied a post-translational modification that was induced by the presence of hydrogen peroxide. This research was very preliminary, but in the future, it can be used to study the short-term and long-term effects of low doses of hydrogen peroxide, as little research has been done on the topic.

GSSM rising senior Ashani Ranwala in the research lab of SmartState Endowed Chair Dr. Kenneth Tew.

I met Dr. Tew on my second day. He talked to me about my plans for the summer and my future goals, and gave me a tour of the lab. Most of my interaction with Dr. Tew was through weekly lab meetings, his visits to the lab, and bimonthly discussion groups. Dr. Tew took the time to work with me individually on my final research presentation, to make sure I fully understood the mechanism I had studied, and provided feedback as I presented in front of his lab group.

I learned so much in my lab, and I am grateful for the experience to work with Dr. Tew!

2012 SmartState-GSSM Interns

SmartState Endowed Chairs again hosted SC Governor's School in Science and Mathematics rising seniors for special summer laboratory internships. These students now know firsthand that their home state of South Carolina provides world-class science and engineering educational opportunities for their under-graduate and graduate school futures.

Riley Blocker
Beaufort, SC
Mentored by:
Dr. John Lemasters (MUSC)
Cancer Drug Discovery Center

Sheryl Boddu
Darlington, SC
Mentored by:
Dr. Martin Morad (USC)
Regenerative Medicine Center

Rachel Chen
Central, SC
Mentored by:
Dr. Patrick Woster (MUSC)
Cancer Drug Discovery Center

Brian Hurst
Rock Hill, SC
Mentored by:
Dr. Jochen Lauterbach (USC)
Strategic Approaches to the Generation of Electricity Center

Ashani Ranwala
Summerville, SC
Mentored by:
Dr. Kenneth Tew (MUSC)
Translational Cancer Therapeutic Center

MUSC SmartState Endowed Chair Dr. Chanita Hughes-Halbert

SmartState Chair Has a Personal Stake in Eliminating SC Health Disparities

The elderly African-American man had recently moved to South Carolina from New York City. He had no job, but he needed specialty medical care. As he talks of his encounter with the state's healthcare system, his voice reflects emotional pain. "The first thing that doctor asked me was did I have insurance. I said no, and he said he wouldn't see me. I couldn't believe it; he didn't even ask what was wrong. I could have been dying. That hurt me; it hurt me to my heart."

An older African-American woman listening to his story nods in agreement. "You can talk all you want (to doctors), but they are going to do what they want to do. I can't change a thing."

This sense of powerlessness among South Carolina's low-income minorities as it relates to health care is common. There are tangible and intangible barriers to care that certain populations in the Palmetto State experience with regularity. As a result, the state's vulnerable communities have alarming health statistics particularly in the area of cancer, where African-Americans make up 30 percent of the population yet have a cancer rate twice that of Caucasians. Consider these facts:

- African-American women are 60% more likely than Caucasian women to die of breast cancer post-diagnosis. This is the largest national disparity.
- African-American men are 80% more likely to get prostate cancer than Caucasian men, and two-and-a-half times more likely to die from it.
- African-American men are 44% more likely to be diagnosed with oral and pharyngeal cancers, which make up the majority of head and neck cancers. Nationally, the disparity is 18%.

Dr. Chanita Hughes-Halbert is the SmartState AT&T Distinguished Endowed Chair in Cancer Equity in the Cancer Disparities Center of Economic Excellence, a collaboration between MUSC, USC and South Carolina State University. Internationally known for her research in health disparities, she was recruited to the Medical University of South Carolina to help define the complex reasons for disparities and identify solutions.

MUSC President Ray Greenberg says Dr. Hughes-Halbert's work is critical to the state's economic success. "For many health conditions, South Carolina has a wide range of outcomes, with the greatest burden of illness falling upon our most vulnerable communities—those with high rates of poverty, those in rural parts of the state and those with high proportions of minority residents," says Dr. Greenberg. "Dr. Hughes-Halbert brings considerable expertise in working with these communities, and to the extent that we can improve the health status of these populations, we can bring economic benefits to the state through better school performance, increased workforce productivity, and lowered health care expenditures."

Corporations understand the connection between health and economic prosperity. Many are placing greater emphasis on prevention and wellness efforts to bring down employee healthcare costs. The AT&T Foundation is a believer. The Foundation provided $1 million in funding to the Cancer

> "The AT&T Foundation is a believer. The Foundation provided $1 million in funding to the Cancer Disparities SmartState Center and to Dr. Hughes-Halbert's research."

Disparities SmartState Center and Dr. Hughes-Halbert's research. The investment will be used to provide free prostate cancer screenings, treatment advice, and screenings to 500 African-American men in South Carolina.

Prior to moving to South Carolina in December 2011 and assuming her SmartState Endowed Chair, Dr. Hughes-Halbert was director of Community-based Research & Health Disparities at the University of Pennsylvania. She also served as director of the Community and Diversity Initiative at the Abramson Cancer Center.

The issue of cancer disparity is personal. She lost her mother to breast cancer at the age of 36. "Her doctors assured us the cancer was caught early, but it was aggressive. She passed away too young," says Dr. Hughes-Halbert.

Dr. Hughes-Halbert is passionate about her work and making South Carolina a model on how to eliminate barriers to needed health care services. She came to MUSC because of the unparalleled commitment of the university and that of businesses like AT&T to change an unfortunate status quo: "Health disparities fall along several lines: race and ethnicity, geographic barriers, and education and income. Often the solutions are as complex as the problems."

"For example, a colonoscopy can identify problems in early, pre-cancerous stages as well as diagnose early-stage colon cancer. Yet African-Americans don't get colonoscopies. Money is an issue; insurance is an issue; a lack of confidence in navigating the healthcare system, and beliefs about the procedure itself; these are all barriers."

Dr. Hughes-Halbert is developing research to understand how disadvantaged populations make decisions about cancer screenings. She is also working with healthcare partners at MUSC and fostering partnerships with other groups across the state to increase minority access to care, improve access to technology that enhances the delivery of care, and raise the health literacy across all populations.

Melanie Jefferson *(left)* from the MUSC Department of Psychiatry discusses cancer disparity strategies with MUSC SmartState Endowed Chair Dr. Hughes-Halbert.

Dr. Hughes-Halbert says that removing financial and educational barriers is not enough. Businesses, communities, and health systems have the responsibility to work together to help people. She is encouraged by South Carolina's early steps to bridge the disparity divide. "I am excited to develop partnerships with other organizations to meet these responsibilities. Universities, communities, and businesses must meet, mesh and use resources so everyone enjoys the personal rewards of better health."

SmartState Endowed Chair
Dr. Joseph Helpern

Leading Health Care Technology Company Licenses SmartState Biomedical Technology

Imagine a beautiful home on Charleston's East Bay Street. The columns soar straight and tall. The porch is wide and inviting. The white paint glistens in the sun. Next, imagine walking into the home. The plaster walls are starting to crack. Doors and windows stick, making them difficult to open. Paint is peeling from the walls. The growing problems are in stark contrast to the flawless external facade.

This is the metaphor Dr. Joseph Helpern, the MUSC SmartState Endowed Chair in the Brain Imaging Center of Economic Excellence (a collaboration between MUSC and USC), uses when explaining the early onset of neurological disorders like Alzheimer's disease, epilepsy and Attention Deficit Hyperactivity Disorder (ADHD). He explains: "You can have a seemingly normal, healthy person going about their day, and deep within their brain, changes are taking place that will alter their lives and their families forever."

Such neurological disorders are common and costly. The Alzheimer's Association reports that 5.4 million Americans live with the disease, which is the sixth leading cause of death in the U.S. In 2012, the cost of caring for Alzheimer's patients is estimated to be $200 billion. Families can expect to pay $42,000 on average per year for nursing home care for loved ones. Worst of all, of course, there is no cure for Alzheimer's disease.

WebMD reports that more than 1 million Americans have epilepsy. Patients with uncontrolled epilepsy have about $10,000 per year in direct medical costs, while the disorder costs patients with controlled cases about $2,000 per year. The cost of diagnosis and treatment is likely to increase as the U.S. population ages. There is also no cure for epilepsy, although many patients can be helped with medication or surgery.

A greater understanding of how Alzheimer's disease, epilepsy, and other neurological disorders develop and progress could lead to earlier diagnosis and new methods to treat and possibly prevent them, says Dr. Helpern. An international pioneer in Magnetic Resonance Imaging (MRI), Helpern has developed an exciting new brain imaging technology called Diffusional Kurtosis Imaging (DKI). DKI studies the microarchitecture of the brain using the movement (diffusion) of water. During an imaging session, multiple images are created that track how water molecules move in the brain due to thermal energy. These images help researchers, and ultimately physicians, identify "cracks" in the brain's structure (microarchitecture) that occur before symptoms of diseases like Alzheimer's or epilepsy are obvious.

The advantages of DKI as a brain imaging technology are significant, says Dr. Helpern. The process is non-invasive; no surgery is required to study the brain's inner workings. DKI is a highly sensitive diagnostic tool. Finally, by revealing the microarchitecture of the brain and how it works, DKI offers great potential as a commercial imaging technology.

> "Business-university partnerships are critical. Siemens Healthcare deliberately seeks partnerships like we have with Dr. Helpern at MUSC. Diverse stimulation of thought encourages provocative thinking. Our role is pushing innovative ideas like Dr. Helpern's forward and commercializing them."
>
> Michael Wendt, Senior Vice President
> Imaging & Therapy Systems Division
> Siemens Healthcare, North America

Dr. Helpern's breakthrough technology has captured the attention of Siemens Healthcare, which has licensed DKI. Siemens Healthcare is one of the world's largest healthcare industry suppliers and a trendsetter in medical imaging, laboratory diagnostics, medical information technology, and hearing aids.

Michael Wendt is Senior Vice President, Imaging & Therapy Systems Division for Siemens Healthcare, North America. Sales and management of Siemens' imaging equipment are among Wendt's responsibilities. He states that Dr. Helpern's technology fits beautifully with Siemens' technology portfolio: "Our company is at the forefront of technology innovation. Pushing this envelope to new diagnostic and therapeutic frontiers like DKI is where we want to be. DKI pushes the boundaries of neuroimaging."

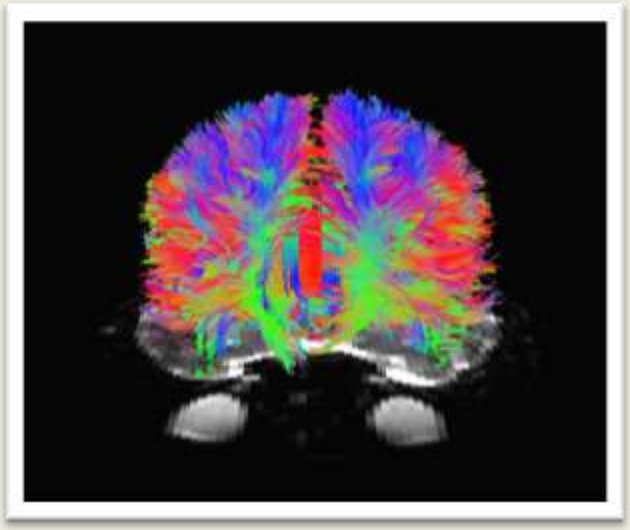
While DKI is a research technology that is not yet FDA-approved and is not currently available to patients, Wendt explains that it is worthy of Siemens' R&D interest: "The brain is one of the final frontiers of medical research. DKI is certainly one of the steppingstones to understanding brain function. We believe it shows promise in opening new pathways for diagnosis and treatment of brain disorders and disease."

Dr. Helpern is a long-time collaborator with Siemens Healthcare. He has been working in the MRI field since its inception. In 1979, he was part of a small group of scientists at Henry Ford Hospital in Detroit that built the largest and most powerful MRI system to date. In 1990, he helped build the first version of the current state-of-the-art 3 Tesla MRI system.

Dr. Helpern created the next generation of brain imaging, DKI, while at New York University, and has continued his work since coming to MUSC in 2010. Seven Ph.D. faculty members from New York University and other universities followed Dr. Helpern to MUSC, as did Siemens Healthcare.

"Siemens Healthcare relies on researchers like Dr. Helpern to keep us at the forefront," Wendt says. "The research and development done at universities like MUSC is critical to us as it connects us to clinicians, engineers, and physicists who work in close contact with patients. This close collaboration between business, clinicians and patients is essential to Siemens Healthcare continuing to provide the technologies to our partners and to patients."

As pleased as Dr. Helpern is with his work at MUSC and his relationship with Siemens, he also admits Charleston is a wonderful place to be. "My wife and I said, 'These people are too happy in Charleston.' It didn't take long and we were drinking the Kool-Aid, too. It's like living in paradise."



A map of the human brain "wiring" using tractography.

SmartState Endowed Chair
Dr. Eric Johnson

Clemson's Optoelectronics SmartState Chair 'Sheds Light' on Connecting Research to Industry

Light is one hot commodity. To put it another way, the science and engineering of light-based technologies is nearly a trillion dollar global market. And South Carolina is rapidly becoming a global force in this arena.

How and when did light get so big? According to Dr. John Ballato, director of Clemson University's Center for Optical Material Science and Engineering Technology (COMSET), advanced materials, devices, and systems that generate, transmit, manipulate, and utilize light are used in everything from cell phones and medical technology to military defense systems and, of course, light bulbs.

Thanks to COMSET, South Carolina is an international leader in this growing market, specifically in the area of optical materials. Established in 2000, COMSET is an interdisciplinary unit of Clemson's College of Engineering and Science. The researchers and faculty at COMSET excel in developing advanced materials that are needed for optical devices and components. This includes organic LEDs, specialty optical fiber, light-emitting plastics, glasses and crystals.

SmartState Chair Dr. Eric Johnson (center) and his students perform tests on optoelectronic devices for Mid-InfraRed lasers.

Ballato says that even with COMSET's success, something—or someone—was missing. That person was Dr. Eric Johnson, who was recruited to South Carolina to serve as the PalmettoNet Endowed Chair in Optoelectronics at the Optoelectronics Center of Economic Excellence at Clemson. "Eric is truly the 'cherry on top' for South Carolina's optoelectronics industry," Ballato says. "He has worked in industry and run start-up companies. He knows how to take the materials developed at COMSET and apply them to commercially viable technologies like lasers and optical components. In short, he's our 'device guy' who will help catapult South Carolina to the forefront of business and job creation in optoelectronics and accelerate the rate at which we move innovations to market."

Dr. Johnson's "secret sauce" is his experience in industry and as an entrepreneur. He has worked at Martin Marietta, Teledyne Brown, SY Technology, and Digital Optics Corporation. He also served as CEO of start-up company Femoptics, LLC. His business experience is invaluable in a world where products must move from lab to market quickly.

Dr. Johnson's academic pedigree is equally impressive. He earned degrees in physics, electrical sciences and electrical engineering and is a fellow at the Optical Society of America as well as the International Society for Optics and Photonics. Prior to joining Clemson, he

Dr. Johnson's "secret sauce" is his experience in industry and as an entrepreneur. He has worked at Martin Marietta, Teledyne Brown, SY Technology, and Digital Optics Corporation. He also served as CEO of start-up company Femoptics LLC.

was a professor at the University of North Carolina-Charlotte. He also served as program director at the National Science Foundation (NSF) and is the recipient of the NSF's CAREER Award.

Dr. Johnson concurs that having an industry and academic background is advantageous to conducting research intended to advance South Carolina's economy. "Speed to market was one of the most important lessons I learned in industry," says Dr. Johnson. "Companies don't have ten years to develop ideas. The business world moves at light speed and so must university innovation. "

One major research challenge is making new technology "scalable." That is, how does a company make a lot of widgets cheaply and quickly? Without economies of scale in manufacturing, even the best technology may be worthless.

Dr. Johnson's work centers on advanced design and manufacturing techniques for photonic devices used in sensing, imaging, and communications. Some of his major innovations include the development of methods for fabricating three-dimensional micro- and nano-optics (meta-optics), high-power lasers, novel integrated fiber beam shaping devices utilizing multimode interference, sensors, fiber lasers, data communications, and passive optics for spectral and polarization filtering. He holds 13 patents and has received more than $15 million in externally funded university and small business research grants.

Dr. Johnson takes a practical approach to research, pushing himself and his students to consider and exploit the manufacturing aspects of new technologies. He says making technology applicable from day one is invaluable to businesses that need innovation now: "Businesses require innovative technology to survive, whether it's a new material, a component or an optoelectronic device that can be brought to market quickly. That is what our SmartState Center is focused on."

There is another critical aspect of his work: preparing students for careers. One of the criteria of high-tech manufacturing companies is the availability of a "knowledge-economy" workforce prepared for demanding jobs in engineering, design and on manufacturing lines. Dr. Johnson makes sure his students understand how to exploit manufacturing technology, something that makes them attractive to corporate employers: "When you have students with practical knowledge beyond textbooks and theory, companies are more interested in them when they graduate."

COMSET and Dr. Johnson's lab are housed in the Clemson Advanced Materials Research Laboratory, a $21M state-of-the-art building. The facility contains laser and chemical laboratories as well as clean rooms and instrumentation facilities for 180 researchers.

The Proterra EcoRide™ BE-35Electric Bus

Mass Transit Goes Green

When gas prices soared in early 2012, mass transit systems like buses, subways, and trains became more attractive to many Americans weary of seeing their paychecks pour into the gas tanks of their cars. Yet some forms of mass transit, buses in particular, carry a bit of stigma. Their diesel engines release unpleasant-smelling exhaust. Buses tend to be loud and uncomfortable for riders. And transit authorities find buses expensive to operate, particularly when fuel prices go north and stay north.

In 2004, serial entrepreneur Dale Hill founded Proterra with a vision of designing and manufacturing world-leading, advanced technology heavy-duty buses powered solely by clean domestic fuels, a need expressed by the Federal Transit Administration (FTA). Hill had already experienced success building buses; in the 1990s, he launched the first and most successful fleet of alternative fuel buses in Denver that are still running today.

Proterra's first "bus of tomorrow" is the fast charge EcoRide™ BE-35 battery-electric bus, which has established the company as the leading global innovator of zero-emission commercial vehicle solutions.

Fast-forward to 2010 when Proterra announced plans to build a full scale, state-of-the-art research and development center and manufacturing plant on the campus of the Clemson University International Center for Automotive Research (CU-ICAR) in Greenville. Proterra could have moved its operations in Golden, Colorado, anywhere in the world, but chose Greenville because of CU-ICAR and the SmartState Program.

Locating near CU-ICAR, which has four SmartState Endowed Chairs who are experts in automotive design, engineering and manufacturing, gives Proterra access to tremendous research and development resources while the company built its EcoRide™ BE-35, next generation zero-emission vehicles, and FastFill™ Charging Stations. Locating near CU-ICAR also gives Proterra access to CU-ICAR automotive engineering graduates.

Says Proterra CEO David Bennett, "South Carolina was a great fit for us. We had support from the community, from government, and Clemson. We also knew we could attract and retain good employees."

From a business perspective, locating in South Carolina opened the door to a powerful relationship with the City of Seneca, South Carolina, which in November 2011 placed the largest order in Proterra's history for its all-electric, zero-emission buses.

The City of Seneca received a $4.1 million FTA TIGGER (Transit Investment in Greenhouse Gas and Energy Reduction) grant to replace Seneca's current fleet of diesel buses with fast-charge, battery-electric buses built locally in South Carolina by Proterra. The City of Seneca also had additional funds from public and private sources to purchase the buses.

> "Our goal is to build more than 1,500 buses per year and to grow our company to 1,300 employees over the next several years."
> Proterra CEO David Bennett

Clemson Area Transit (CATbus) general manager Al Babinicz says the order of Proterra's all-electric, zero-emission buses makes Seneca the first city in the nation to have an all-electric bus system. It is a fact made all the sweeter since the buses are made in South Carolina.

Proterra could not ask for a better cheerleader than Babinicz for its "green" buses: "These busses are going to solve a lot of problems. The fuel costs are lower. There are zero emissions, so we're protecting our environment. The buses are quiet and comfortable. They are easy and inexpensive to maintain. And buying from Proterra means we are creating jobs here in South Carolina."

Bennett is equally pleased to put his company's "Made in South Carolina" buses on the road in the Upstate: "Our goal is to build more than 1,500 buses per year and to grow our company to 1,300 employees over the next several years. In less than a year, we've grown from approximately 40 employees in Greenville in June 2011 to more than 130 employees in June 2012. That's a 400 percent increase, and Seneca's order helped put South Carolinians to work at Proterra."

In addition to the City of Seneca order, Proterra also has bus orders from communities in Texas, Florida, and California. The attraction is simple: the zero-emission buses are clean, green, and cost-efficient.

"Transit companies spend an average of $1.05 a mile on diesel buses. Our buses cost just 18 cents per mile to operate," says Bennett.

For CATbus, which allows riders to use its transit for free, the fuel savings are too good to pass up. Babinicz explains, "We are transporting people to and from three counties, five municipalities and four universities; that's a lot of miles! We will have tremendous savings when we move to our new all-electric buses in early 2013."

Proterra's relationship with the City of Seneca promises to get even better. As the battery range of the buses improves, CATbus will expand the number of Proterra buses in service and increase route numbers. Eventually, says Babinicz, the city hopes to install solar panels to fuel the buses. He smiles. "How green is that?"

"We will be a model for the world," says Babinicz. "What makes it even better is that these buses are made in South Carolina by South Carolinians. This is big!"

SmartState Endowed Chair
Dr. Jochen Lauterbach

USC Researcher, SC Power Companies Work to Keep Coal-Fired Electricity Affordable, Available & Green

Coal is plentiful. Coal is affordable. Thus, South Carolina relies on coal to produce a significant amount of the electricity that heats and cools its homes and powers its businesses. In addition, plentiful and affordable electricity from this "black gold" has long been an incentive that economic developers have offered corporations seeking a low-cost, business friendly location.

State-owned electric and water utility company Santee Cooper generates 70 percent of its electricity from coal. More than 2 million South Carolinians depend on that electricity, including 29 large industrial customers spread over ten counties. Santee Cooper is also the primary source of power distributed by the state's 20 electric cooperatives.

"Coal has been the backbone of American energy for years. Environmental Protection Agency regulations—designed to limit harmful emissions—pose a challenge for older coal-fired electric plants too costly to retrofit with new clean air technologies," says Mike Davis, manager of Santee Cooper's Jefferies Generating Station, which includes coal-fired, hydroelectric, and oil-fired power production plants. "That being said, one of Santee Cooper's missions as an environmental steward is to balance electricity generation with emissions control."

He adds, "Our goal in working with Dr. Jochen Lauterbach and his research team at the University of South Carolina on clean coal technologies is to develop new ways to achieve those clean air standards while keeping coal-fired electricity production affordable for our residential and business customers."

Dr. Lauterbach holds the SmartState Endowed Chair in the Center for Strategic Approaches to the Generation of Electricity (SAGE), one of USC's six energy-related SmartState Centers of Economic Excellence encompassing fuel cell, nuclear energy, and fossil fuel technologies.

A highly recognized chemical engineer known for his expertise in resolving industrial challenges, Dr. Lauterbach is working closely with Santee Cooper, the Electric Cooperatives of South Carolina, and other utility partners to improve environmental control technologies for coal-fired power plants. This work includes improving emission controls and developing new nanomaterials and processes to capture and store or to find a use for carbon emissions.

"There is no question that emissions from burning coal need to be managed, " Dr. Lauterbach says. "That's why power companies have focused on controlling those emissions and are working through this Center to contain them to the degree possible."

That is not where the story ends, however. What makes Dr. Lauterbach and his team so valuable to utility companies is that his research focus extends beyond improving environmental control technologies to developing novel approaches for electricity generation. These approaches include developing new materials and processes for carbon emission capture, storage, and use.

One initiative with Santee Cooper is an abatement project in which Dr. Lauterbach and Dr. Bihter Padak are working on materials to capture emissions.

USC: Dr. Jochen Lauterbach

Research focus for the SAGE Center covers more than coal. Our premier research facility is dedicated to combinatorial discovery of materials, in close collaboration with industrial partners. Several exciting research projects using this methodology focus on the discovery of nanomaterials for energy applications. With power generation subject to exacting environmental regulation, demand grows for gas sensors capable of measuring multiple chemicals in combustion atmospheres where temperatures exceed 1,273 K. Our work has focused on the combinatorial discovery and optimization of novel electrochemical gas sensing materials for thin-film gas sensor arrays.

Jet turbines are one of a plane's most engineered components, with multiple layers devoted to protecting the superalloy turbine blades from high temperatures (as high as 1,873 K), CMAS, and oxidation. SAGE has recently developed the first comprehensive high-throughput methodology, identifying novel chemical and oxidation resistant materials, which permits in situ monitoring of chemical reactions and oxide formation over large portions of a multi-component phase space.

Work is also being performed in fundamental studies of catalyst synthesis and catalytic reactions for synthetic fuel production using a wide array of experimental techniques.

--SmartState Endowed Chair
Dr. Jochen Lauterbach

Dr. Padak, a chemical engineer who came to USC from Stanford University, explains: "When coal is burned, there are certain materials that will bind to the chemicals released, preventing them from entering the atmosphere. We are currently conducting molecular modeling to determine what materials work best. Our next step is testing the most promising materials in the lab and ultimately at Santee Cooper."

Dr. Padak adds: "We believe this technology could potentially offer a solution to electric power generating companies in South Carolina and across the United States, which can help bridge the gap between coal and future, cleaner technologies such as solar energy."

Santee Cooper has already reduced emissions by 90 percent at two of its largest coal-fired electric utilities. Davis thinks USC's work can keep affordable coal-fired power plants generating low cost electricity for South Carolina: "USC's research is helpful to Santee Cooper and to the state. We want to keep coal economical—and green—so we have electricity everyone can afford. Dr. Lauterbach and his team are energetic and committed to bringing us solutions to use in our environmental protection efforts."

Dr. Lauterbach smiles at the vote of confidence, then gets serious. "This is an issue of national energy security. We have over 200 years of coal supply in the United States. But we need to meet the environmental challenges involved in using that coal to support our country's energy independence, and we need to be ready with technologies to deploy for our utilities."

from left **Dr. Lauterbach, Dr. Simpers, and Dr. Padak in the SAGE Center's Horizon high-throughput catalysis laboratory.**

SmartState Endowed Chair Dr. Igor Roninson

USC Adds Top Drug Researcher in the Quest to Cure Cancer

A cancer diagnosis is a raw deal. One in five Americans will hear his or her doctor intone it. One in four Americans will succumb to the disease.

Even though the fight against cancer has raged for decades, the disease would seem to be winning. Eradicating, or simply stopping it from progressing, is difficult. The reason: cancer cells closely resemble healthy cells—with subtle, life-threatening differences. As a result, chemotherapy drugs used to fight cancer have a difficult time distinguishing cancer cells from healthy cells. Hence, the well-known side effects like nausea, hair loss, ulcerations, and suppression of the immune system when undergoing chemotherapy.

Drugs offer one of only a few approaches to treat a cancer which has spread. Most researchers focus on identifying drugs that either kill cancer cells or reduce the size of tumors by inhibiting the cancer cells' ability to divide. The odds of success are slim. Of the thousands of natural and synthetic chemical compounds tested for anticancer activity over the last 50 years, only about 25 are commercially available to patients today.

Despite the long odds, researchers around the world continue the search for answers, including a growing cadre of cancer and drug development experts drawn to South Carolina by the SmartState Program. The Palmetto State has stacked the deck and is now home to nine SmartState Endowed Chairs who focus on drug development and discovery. Of these nine, six address cancer drug development.

The most recent appointment is Dr. Igor Roninson, who arrived to South Carolina in April 2011. Winner of the American Association for Cancer Research (AACR) Award for Meritorious Achievement in Cancer Research and the Life Extension Prize from the Regenerative Medicine Secretariat, Roninson is the internationally acclaimed scientist-educator who holds the SmartState Endowed Chair in Translational Cancer Therapeutics at the South Carolina College of Pharmacy (SCCP).

The Translational Cancer Therapeutics Center of Economic Excellence is a joint academic program between the University of South Carolina (USC) and the Medical University of South Carolina (MUSC). Roninson's SmartState laboratory and research team is physically located on SCCP's USC campus. Here he is carving out new territory in the fight against cancer through pharmacogenomics—the study of how an individual's genes impact the body's response to drugs. His focus on the development of novel drugs and approaches for the treatment of cancer is currently centered on a new drug that alleviates chemotherapy side effects and enables cancer patients to better tolerate and benefit from it.

In his three decades fighting against cancer, Dr. Roninson has numerous accomplishments, including exposing cancer's multi-drug resistance mechanism and how to induce aging in tumor cells using chemotherapy. A prolific researcher and innovator, he holds 39 U.S. patents on his discoveries and has authored more than 160 articles.

A prolific researcher and innovator, Roninson holds 39 U.S. patents. He is also a successful entrepreneur. Dr. Roninson is the president and chief scientific officer of Senex Biotechnology Inc., which he relocated to Columbia.

His motivation is simple: at age five, he lost his beloved grandfather to cancer. "That made me decide then and there that I was going to cure cancer," he recalls.

Dr. Roninson is also a successful entrepreneur. He is the president and chief scientific officer of Senex Biotechnology Inc., which he relocated to Columbia. The company focuses on cellular senescence research—when cells stop dividing but do not die, and instead secrete proteins that contribute to cancer growth and other age-related diseases. The company has developed two classes of compounds that inhibit the production of these secreted proteins and prevent side effects of cancer chemotherapy.

"Dr. Roninson is an ideal match for the Center," said Joseph T. DiPiro, executive dean of the SCCP. "His innovative thinking in the lab and in the classroom will be a major benefit not only to the College and to our students but also to the state of South Carolina. Our research program is already recognized as one of the best, and Dr. Roninson's contributions will certainly enhance it further."

In 2010, the SCCP was ranked third in the country in percent of Ph.D. faculty with National Institutes for Health funding. In 2011, Dr. Roninson's company, Senex Biotechnology, was awarded a $1.5 million grant from the National Cancer Institute. In addition, his SmartState Center, which includes the research team of MUSC SmartState Chair Dr. Kenneth Tew, has extramural research funding in excess of $13.4 million.

Dr. Roninson was attracted to South Carolina by opportunities for collaboration with excellent cancer drug discovery scientists whose interests are close to his own: "The only way to make this kind of biomedical research work succeed is to spread a collaborative umbrella. In this regard, South Carolina is unique in that it merges two independent universities, MUSC and USC, a school of pharmacy, and the Greenville Hospital System. There is an umbrella of different institutions working together and that is what brought me here." He adds that the state's entrepreneur support program, SCLaunch, was another appealing factor. "We see great opportunities for two-way collaboration here: Senex scientists offering expertise in drug discovery and drug development, and South Carolina scientists using Senex's compounds as tools for their biological research.

The ability to quickly conduct robotic screening of hundreds of thousands of drug-like chemicals with machines like this high-throughput screener greatly enhances the research of biomedical scholars like Dr. Roninson.

SmartState
SC Centers of Economic Excellence

CLEMSON UNIVERSITY

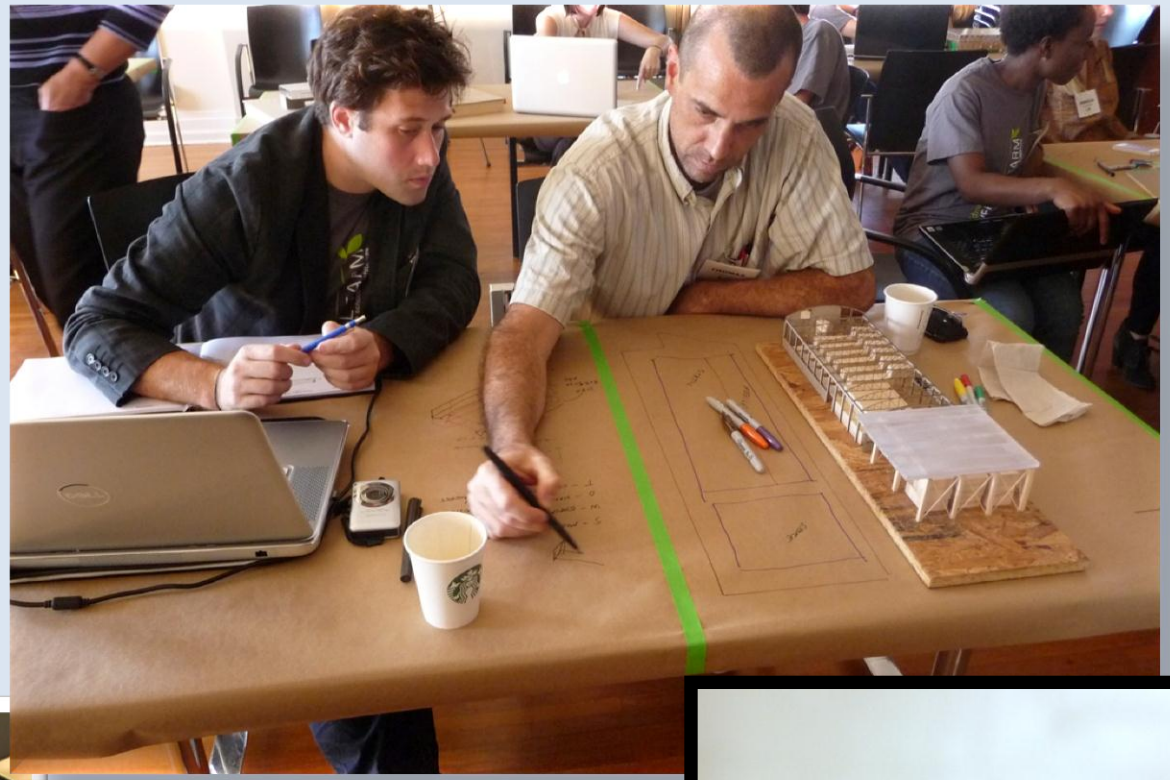
12 Centers
15 SmartState Chairs

UNIVERSITY OF SOUTH CAROLINA

17 Centers
30 SmartState Chairs

MUSC
MEDICAL UNIVERSITY of SOUTH CAROLINA

19 Centers
41 SmartState Chairs



Center Summaries

SmartState
SC Centers of Economic Excellence

AUTOMOTIVE AND TRANSPORTATION TECHNOLOGY

[SEE CU-ICAR ARTICLE ON PAGE 27.]

CLEMSON UNIVERSITY

CU-ICAR
TOMORROW'S ENGINEER TODAY

4 CENTERS
4 SMARTSTATE CHAIRS

Dr. Zoran Filipi, the new Timken Endowed Chair in Automotive Design and Development.

Automotive Manufacturing

Award Date: 2003 **State Award Amount:** $5 million **Institution:** Clemson
BMW Endowed Chair in Manufacturing: Clemson is actively recruiting.
Extramural Research Above Matching Requirement: $7.5 million

The Center develops novel micro-electromechanical systems technologies for manufacturing and improving the efficiency of manufacturing large, complex objects. In FY 2012, Center personnel continued research on the up-armor of civilian vehicles with titanium armor. Faculty for the Center received a $2.3 million NSF grant to create a workforce development center for the aviation and automotive technology fields. Also, CU-ICAR hosted the second Automotive Transatlantic Summit with the theme "Winning the Future of Global Automotive-Collaborative Best Practices and Innovative International Models."

Automotive Design & Development

Award Date: 2003 **State Award Amount:** $5 million **Institution:** Clemson
Extramural Research Above Matching Requirement: $2.4 million
Timken Endowed Chair in Automotive Design & Development: Dr. Zoran Filipi

With the recent appointment of Dr. Filipi, this Center now focuses on research and design of advanced powertrains including internal combustion engines, hybrid vehicles, and electric vehicles, along with lightweight design and materials, functional integration, and structural dynamics. Along with other CU-ICAR Centers, Dr. Filipi and his research team partnered with Hertz Corporation and Duke Energy to install Evatran's Plugless Power wireless electric vehicle charging technology. According to an Evatran press release, "these installations, on Nissan LEAF vehicles, represent the first passenger electric vehicles in the world with full wireless charging capability." Clemson students will test drive the vehicles and research any other possible applications for the wireless technology.

Vehicle Electronic Systems Integration

Award Date: 2004 **State Award Amount:** $3 million **Institution:** Clemson
Michelin Endowed Chair in Vehicle Electronic Systems Integration: Dr. Todd Hubing
Extramural Research Above Matching Requirement: $2.5 million

SmartState Chair Dr. Hubing researches vehicle and aerospace electronics, a complex field where components such as software, telematics, information systems, electronics, mechatronics, and sensors must be integrated in a well-balanced way to create attractive, stable products. Currently, the Center's research is focused in three main areas: development of new design and test practices to ensure reliability of automotive electronic controls; development of new power-inverter technology that is expected to reduce the size and weight of motor drivers and electric storage devices in electric and hybrid electric vehicles; and development of computer algorithms for "listening" to the electromagnetic emissions from vehicles to recognize potential system failures before they occur.

Automotive Systems Integration

Award Date: 2003 **State Award Amount:** $5 million **Institution:** Clemson
BMW Endowed Chair in Automotive Systems Integration: Dr. Paul Venhovens
Extramural Research Above Matching Requirement: $1.8 million

In addition to the Deep Orange Project, this Center focuses research in four areas of automotive systems: diagnostics and prognostics; sustainable mobility; concepts; and methods and tools. In FY 2012, Center researchers completed a project that studied the aging process of hybrid electric vehicle battery packs and implemented a test procedure to assess battery packs. Another Center project focused on deriving a simple, flexible energy management control strategy for plug-in hybrid electric vehicles in order to minimize the overall costs of distance driving. Dr. Venhovens and his team have started work on Deep Orange IV—a year-long project in which CU-ICAR graduate students design and construct a prototype vehicle. Deep Orange IV will highlight a low-volume production system within a large volume manufacturing concept and is the first Deep Orange Project to involve industry partners only from South Carolina. The ongoing Deep Orange III project showcases hybrid powertrain and infotainment architecture; once the vehicle prototype is completed (calendar year 2012), it will be shown at automotive shows throughout the world.

Supply Chain Optimization & Logistics Center

[not a CU-ICAR automotive Center]
Award Date: 2005 **State Award Amount:** $2M **Institution:** Clemson
Fluor Endowed Chair in the Supply Chain Optimization and Logistics Center: Dr. Scott Mason
Extramural Research Above Matching Requirement: $8.3M

This Center researches supply chain modeling, material handling, logistics, planning systems, and distribution. Fluor is a full match investor for this Center. More than 100 working professionals are enrolled in an online Capital Projects Supply Chain master's degree related to this Center; the program's innovative learning approach allows students to participate even when faced with relocations to new project sites or offices. In FY 2012, client projects included studying and solving material delivery routes within Milliken & Company plants to improve product flow, as well as enhancing and standardizing existing processes and developing protocol and procedures in support of tool control for Boeing.

CU-ICAR doctoral students Xueye Zhang (forefront) and Shuonan Xu make preparations for an Engine-In-the-Loop test, where a real engine runs concurrently with a simulated vehicle to gain insight about fuel economy and emissions of a prototype concept.

SmartState
SC Centers of Economic Excellence

Future Fuels™

University of South Carolina

6 Centers
7 SmartState Chairs

SmartState Chair Dr. Kenneth Reifsnider, distinguished member of the National Academy of Engineering.

Hydrogen Economy

Award Date: 2004 **State Award Amount:** $5 million **Institution:** USC

Extramural Research Above Matching Requirement: $43.1 million

Chairs: USC is recruiting an Innovation SmartState Chair and a Discovery SmartState Chair.

This Center develops hydrogen storage materials for electricity production. The Center's scope was enhanced in FY 2012 to advance the science associated with clean, secure renewable energy technologies and transportation fuel. One startup company, Hydrogen Hybrid Mobility, has been created. USC has the nation's only NSF Industry/University Cooperative Research Center for Fuel Cells, which was renewed in FY 2009 for five years. Center researchers received over $7 million in grants in FY 2012. Multiple projects are funded by the Office of Naval Research to improve electric and technological systems in naval ships.

Solid Oxide Fuel Cells

Award Date: 2006 **State Award Amount**: $3 million **Institution:** USC

Extramural Research Above Matching Requirement: $49.5 million

SmartState Endowed Chair in Solid Oxide Fuel Cell Research: Dr. Kenneth Reifsnider

Solid oxide fuel cells are one of two leading fuel cell types expected to find commercialized application in large, high-power systems such as full-scale industrial and large-scale electricity-generating stations. Applications for these fuel cells include large-scale power distribution for municipalities, rural areas and industries, as well as energy for homes. They could also provide mobile power for computers, cell phones, and other electronics. Work associated with this Center has led to the creation of a "clean-tech" startup company, NextGenn, Inc. In 2012, the Center completed a two-year collaboration with DARPA, Protonex Technology and two other SmartState Centers to research hydrogen batteries for soldier power systems. In addition to remarkable extramural research figures or industry collaboration, education and outreach are Center hallmarks. Center personnel have participated in and led numerous workshops, presentations, and in-service training for elementary and middle school teachers. The primary reason for these outreach services preparing teachers to teach engineering principles, a near-future federal curriculum requirement.

Strategic Approaches to the Generation of Electricity

Award Date: 2007 **State Award Amount:** $5 million **Institution:** USC

Extramural Research Above Matching Requirement: $19.7 million

SmartState Chair in Strategic Approaches to the Generation of Electricity at USC: Dr. Jochen Lauterbach

The long-term research objective of the Center is to improve environmental control technologies for coal power plants, including the design of improved environmental control systems for mercury and acid gas emission control, as well as the development of new materials and processes for carbon sequestration and storage/utilization. Research is performed on novel de-NOx catalysts for power plants, the enhancement of the multi-pollutant performance of such catalysts, the measurement of trace metals in flue gas, CO2 capture from flue gas, and improvement of combustion processes. Working with two other SmartState Centers and DARPA, this Center developed a process to convert jet fuel into a liquefied petroleum gas-like fuel for use in portable fuel cell power packs. [See Center profile article on page 29.]

Catalysis for Renewable Fuels

Award Date: 2005 **State Award Amount:** $3 million **Institution:** USC
Extramural Research Above Matching Requirement: $17.5 million
Renewable Fuel Cells Chair: Dr. John Regalbuto

New SmartState Chair Dr. John Regalbuto and his team are developing catalysts that allow alternative fuels to be produced from renewable sources. These new catalysts are the "next wellhead" as the transportation sector moves to less dependence on imported oil and carbon fuel. Two objectives of the Center include synthesis of inorganic catalysts for the conversion of biomass to biofuels and synthesis of electrocatalysts for solar fuels and fuel cells. Research at this Center has led to the creation of two startup companies, Palmetto Fuel Cell Technologies and Regal Solutions. Regal Solutions was created to revolutionize mixing processes in the chemical and construction industry.

Nuclear Science and Energy

Award Date: 2008 **State Award:** $3M **Institution:** USC
Extramural Research Above Match Requirement: $10.8M
Endowed Chair in Advanced Materials and Nuclear Power:
Dr. Dan Gabriel Cacuci

A number of corporations have invested in this Center, including Duke Energy, Progress Energy, SCANA, and Westinghouse. The Center is building international collaborations and has focused on proposals to the European Union related to the next evolution of Nuresim, a simulation platform for nuclear reactor safety. New SmartState Chair Dr. Cacuci is a world-renowned nuclear engineer and is the author of *The Handbook of Nuclear Engineering*, as well as the editor of the journal *Nuclear Science and Engineering*.

General Atomics for the Development of Transformational Nuclear Technologies

Award Date: 2009 **State Award:** $3M **Institution:** USC
Extramural Research Above Matching Requirement: $4.8M
Chair: USC is recruiting a CHAIR IN ENERGY & NUCLEAR SECURITY.

This Center focuses on transformational technologies in solving energy problems to increase nuclear efficiency, safety, and sustainability. Center personnel have developed proposals related to advanced accident tolerant fuels; such research seeks to prevent accidents similar to the Fukushima nuclear disaster. The Center has received a $900,000 match commitment from California company General Atomics.

SmartState Chair Dr. Regalbuto (left) of the Catalysis for Renewable Fuels Center guides a student through a catalysis experiment.

SmartState
SC Centers of Economic Excellence

NANOTECHNOLOGY

UNIVERSITY OF SOUTH CAROLINA

3 CENTERS
3 SMARTSTATE CHAIRS

(l to r) USC SmartState Endowed Chairs Dr. Ken Reifsnider, Dr. Jochen Lauterbach, U.S. Secretary of Energy and Nobel laureate Dr. Steven Chu, and SmartState Endowed Chair Dr. Brian Benicewicz of the Polymer Nanocomposites Center of Economic Excellence.

Experimental Nanoscale Physics

Award Date: 2003 **State Award Amount:** $4 million **Institution:** USC

Extramural Research Above Matching Requirement: $8.6 million

SmartState Endowed Chair in Experimental Nanoscale Physics: Dr. Richard Webb

Research by Center faculty member Dr. Thomas Crawford for assembling nanomaterials into macroscopic patterns with nanometer resolution has led to the creation of a startup company MagAssemble, LLC. The technology produced by MagAssemble could result in novel approaches for the defense, energy, and healthcare sectors. The Center has formed the Carolina Alliance for Energy Technology Nanomanufacturing with Clemson University and Sandia National Laboratories for exploration and production of large and efficient solar photovoltaic arrays potentially capable of meeting a significant amount of our future energy needs.

Polymer Nanocomposites

Award Date: 2004 **State Award Amount:** $3.5 million **Institution:** USC

Extramural Research Above Matching Requirement: $16.8 million

SmartState Endowed Chair in Materials Science and Engineering: Dr. Brian Benicewicz

Research on elastomer nanocomposite materials has resulted in a two-year project funded by Michelin North America; this work investigates surface functionalization of synthetic layered silicates with sulfur-functional silanes, followed by incorporation in elastomer composites. By replacing silica with layered platelet materials in tire rubber formulations, this work may result in tires with greater fuel efficiency, lower wear, and greater traction. Recent research at the Center has also focused on unresolved issues concerning the controlled dispersion of nanoparticles, and how particle dispersion determines the properties of nanocomposites. Basic work focuses on the development of the synthetic tools needed to precisely control the environment or interface between the nanoparticles and the polymer matrix. With these synthetic tools, the Center is expanding its interests and work to apply knowledge to applications in the fields of optics, electronics, biological and medical and structural materials. Other Center partners include BASF, the U.S. Navy, and PBI Performance Products.

Environmental Nanoscience & Risk

Award Date: 2008 **State Award Amount:** $3 million **Institution:** USC

Extramural Research Above Matching Requirement: $2.7 million

[USC appointed Dr. Jamie Lead as the SMARTSTATE ENDOWED CHAIR FOR NANOENVIRONMENTAL SCIENCE AND RISK in August 2012].

Research at this Center focuses on the scientific, technological, health, economic, legal, and societal effects of nanotechnology on the environment. Nanomaterials are small enough to cross cell membranes and are potentially toxic to living organisms, including humans. The USC College of Engineering and Computing has been awarded an NSF grant to establish a nanotechnology education program for engineering undergraduates. Much of the Center's work on the impact of nanoparticles on the environment has focused on their fate in estuaries, shallow water ecosystems with tidally dependent salinities. In coastal South Carolina, waterborne contaminants reach the ocean by passing through estuaries, groundwater and river deltas. When fresh, organic-rich waters mix with seawater in these environments, many contaminants precipitate out of solution and sink to the bottom.

ADVANCED MATERIALS

3 CENTERS
3 SMARTSTATE CHAIRS

CLEMSON UNIVERSITY

Optical Materials

Award Date: 2004 **Award Amount:** $5 million **Institution:** Clemson
Extramural Research Above Matching Requirement: $33.4 million
Chair: Clemson will recruit the J.E. SIRRINE TEXTILE FOUNDATION CHAIR IN OPTICAL FIBERS.

This Center is affiliated with Clemson's Center for Optical Materials Science and Engineering Technologies (COMSET) and has received major non-state investment from the J.E. Sirrine Textile Foundation. Center researchers have been recognized nationally and internationally for their groundbreaking work: Dr. Roger Stolen was elected to the National Academy of Engineering; Dr. John Ballato became a Fellow of the International Society of Optical Engineering; and four researchers' work on micro-plasma cancer therapy and pressure plasma jet arrays were highlighted as the feature and cover article of five scientific journals.

Advanced Fiber-Based Materials

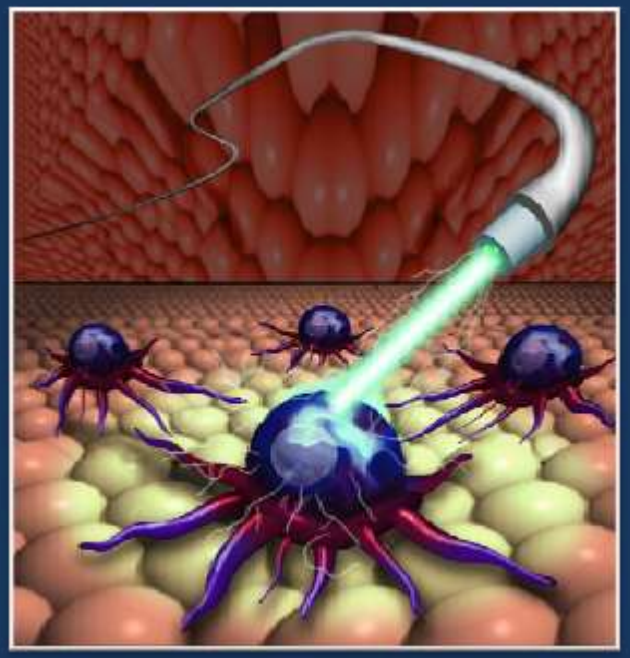
Award Date: 2006 **Award Amount:** $4 million **Institution:** Clemson
Extramural Research Above Matching Requirement: $12.9 million
Chair: Clemson will recruit the J.E. SIRRINE TEXTILE FOUND. CHAIR IN ADVANCED FIBER-BASED MATERIALS.

Research at this Center concentrates on the composition of novel fiber materials, fabrics and integrated components which possess unique functionality and value-added performance over traditional textile materials. This Center is developing a niche industry in high-tech fibers and materials including fiber-reinforced composite materials based on metals, ceramics and polymers. Research focused on capillary surface fibers applied in protein separation led to the creation of a startup company, Specialty Custom Fibers, located in Pendleton, South Carolina.

Optoelectronics

Award Date: 2008 **Award Amount:** $2 million **Institution:** Clemson
Extramural Research Above Matching Requirement: $2.4 million
PalmettoNet Endowed Chair in Optoelectronics: Dr. Eric Johnson

This Center focuses on improving devices, systems and protocols used in high-speed optical communication networks. This Center advances research in optoelectronics and optical communications theory and practice and seeks to meet the industry need for higher data rates and lower latency for switching and routing in optical networks. In FY2012, faculty members in this Center received grant funding from the Air Force to investigate the use of advanced optical fibers for high power lasers. [See profile of SmartState Endowed Chair Dr. Eric Johnson on page 25.]



Optical Fiber Based Micro-Plasma Endoscope
Pictured is a flexible micro-plasma jet device with a hollow-core optical fiber producing a plasma plume that is quite narrow but long enough to apply direct treatment to tumor cells. This device enables new directed cancer therapies based on highly flexible and precise hollow-core optical fiber-based plasma medicine and offers a unique path to understanding plasma-induced tumor cell apoptosis. Such devices are part of the research at the Optical Materials Center.

Urban Ecology & Restoration

Award Date: 2005 **State Award Amount:** $2 million **Institution:** Clemson

Extramural Research Above Matching Requirement: $9.8 million

Chair: Clemson will recruit the SMARTSTATE ENDOWED CHAIR IN URBAN ECOLOGY AND RESTORATION.

This Center is charged with the creation of applied research in environmental science and engineering, habitat restoration and water quality management; the growth of the South Carolina environmental industry; and provision of leadership in urban ecology projects across the state. The Center has successfully impacted the community of Aiken, South Carolina, where faculty members and city management have lessened the flooding of the Sand River and consequently reduced erosion in the Hitchcock Woods. Other strategies used in the Aiken community include vegetative buffers and rain gardens to prevent erosion; sensors are also used to measure the level of pollutants in the rain water, and high-tech filters are used to prevent harmful pollutants from entering the water supply. Center researchers believe that these projects provide a model to be duplicated not only in other South Carolina communities, but across the nation.

Sustainable Development

Award Date: 2010 **State Award Amount:** $4 million **Institution:** Clemson

Extramural Research Above Matching Requirement: $4.9 million

Chair: Clemson will recruit the THOMAS F. HASH '69 ENDOWED CHAIR IN SUSTAINABLE DEVELOPMENT.

The Center mission includes the development of new technologies to support real-time monitoring and management of natural and built environments. The Intelligent River™ Project has created a wireless sensor called a "MoteStack" that can monitor and transmit environmental data in real time. With a $3 million NSF grant, the Center will use this technology to monitor the 312-mile length of the Savannah River. In response to this specific project, Colonel Edward Kertis, a former U.S. Army Corps of Engineers Commander, wrote: "The technologies being developed will enable us to more adaptively manage the river by optimizing water resource allocation while minimizing impacts on the environment …. The new generation of data-collection platforms could potentially be adopted by every Corps of Engineers water management office."

Dr. Brad Putman of the Urban Ecology and Restoration SmartState Center showcases permeable pavement technology at the Aiken Green Infrastructure Educational Field Day.

2 CENTERS
2 SMARTSTATE CHAIRS

A MoteStack sensor for the Sustainable Development Center of Economic Excellence Intelligent River™ Project.

2 CENTERS
2 SMARTSTATE CHAIRS

CyberInstitute

Award Date: 2008 **State Award Amount:** $2 million **Institution:** Clemson
Extramural Research Above Matching Requirement: $2.7 million
Chair: Clemson will recruit the C. TYCHO HOWLE ENDOWED CHAIR IN COLLABORATIVE COMPUTING ENVIRONMENTS.

This Center concentrates on developing, testing, and evaluating prototype cyberinfrastructure (CI) equipment and programs, leading to stronger collaborative environments for research, education, and technology transfer throughout South Carolina. The Center is currently working on a collaborative project to implement a Global Environment for Network Innovations (GENI) test-bed for experimentation of future Internet protocols and applications on programmable Ethernet, Wi-Fi, and WiMAX networks. This activity places the state in an elite group of research organizations pioneering the next generation Internet.

Data Analysis, Simulation, Imaging, and Visualization

Award Date: 2010 **State Award Amount:** $2 million **Institution:** USC
Extramural Research Above Matching Requirement: $2.4 million
Chair: USC will recruit a SMARTSTATE ENDOWED CHAIR IN DATA ANALYSIS, SIMULATION, IMAGING, AND VISUALIZATION

This Center's objective is to develop cutting-edge science and technology for transforming data into knowledge by extracting information and its faithful representation and visualization. The Center continues to focus on specific high-priority areas including inline data processing, multi-sensor data acquisition, tissue modeling, atomic scale imaging, and bioimaging. Faculty members are developing an open-source software application to reproduce optical soundtracks of motion picture films from digital scans, producing a synchronized sound film file.

1 CENTER
1 CHAIR

Tourism & Economic Development

Award Date: 2005 **State Award Amount**: $2 million
Institutions: USC/Coastal Carolina University
SmartState Endowed Chair in Tourism and Economic Development: Dr. Simon Hudson

Tourism is a state industry responsible for more than $17 billion and which employs more than 200,000 people—approximately 10 percent of the state workforce. This Center's mission is to lead cutting-edge tourism and hospitality research that is relevant and directly applicable to the South Carolina tourism industry. SmartState Endowed Chair Dr. Simon Hudson has spent considerable time traveling the state, making industry connections and creating research partnerships. Along with Center researcher Dr. Meng, Dr. Hudson won Best Research Paper for the 2012 Travel and Tourism Research Association. In FY 2012, the Center developed a tourism and hospitality business incubator in partnership with the USC/Columbia Technology Incubator. The business incubator will provide tourism and hospitality entrepreneurs with strategic help with creating successful businesses.

Neuroscience

5 Centers
15 SmartState Chairs

SmartState Endowed Chair Dr. Chris Rorden of the Brain Imaging Center of Economic Excellence, a collaboration between USC and MUSC.

Brain Imaging

Award Date: 2003 **State Award Amount:** $5 million **Institutions:** USC/MUSC
Extramural Research Above Matching Requirement: $31.3 million
USC Endowed Chair in Neuroimaging Research: Dr. Chris Rorden.
MUSC Endowed Chair in Brain Imaging: Dr. Joseph Helpern.
MUSC Chair II: MUSC is recruiting a second SmartState Endowed Chair in Brain Imaging.

This collaborative Center is creating a world-class brain imaging center, and has initiated its first brain study using TMS (Transcranial Magnetic Stimulation) combined with Functional MRI, a technique installed on the new Siemens 3T MRI scanner at the Center's Advanced Imaging Research facility at MUSC. (TMS provides a short but strong, magnetic field to the brain—useful for studying how the brain works.) Functional MRI is a complementary tool for investigating how the brain works. Using the combined TMS/Functional MRI technique will help with the investigation of treating brain damage, especially stroke-related damage. [See profile of SmartState Chair Dr. Helpern on page 23.]

Vision Science

Award Date: 2005 **State Award Amount:** $4.5 million **Institutions:** MUSC/USC
Extramural Research Above Matching Requirement: $18.1 million
MUSC Chairs: MUSC is two SmartState Endowed Chairs.
USC Chair: USC is recruiting one SmartState Endowed Chair.

In 2012, Center researchers Drs. Beeson and Rohrer began a new company, MitoChem Therapeutics. With funding from the Foundation Fighting Blindness, MitoChem Therapeutics "will develop a cross-cutting treatment for vision-robbing retinal degenerative diseases." The company's innovative approach involves protecting mitochondrial function in cells to potentially slow vision loss caused by conditions such as macular degeneration and retinitis pigmentosa that affect more than 10 million Americans. Researchers at the Center are partnering with various companies including Alcon Labs, Taligen, and Alexion Pharmaceuticals to study new treatments for macular degeneration, development of new anti-glaucoma agents, and innovations in cataract surgery.

Childhood Neurotherapeutics

Award Date: 2006 **State Award Amount:** $5 million **Institutions:** USC/MUSC
Extramural Research Above Matching Requirement: $14.4 million
USC Chairs: USC is recruiting Chairs in Child & Adolescent Neurochemistry and Translational Therapeutics.
MUSC Chair: MUSC is actively recruiting the Neurodevelopmental Dysfunction Chair.

Research at this Center focuses on the prevention of brain damage in premature infants and curing infant brain diseases through cellular engineering. Along with the study of cellular engineering, researchers at the Center are working on an array of cognitive behavioral tasks in transgenic mice to determine if therapeutics can improve functional development outcomes. This research could help aid adolescent humans who struggle with ADHD. Studies have resulted in a startup company, ImmunoMod, which develops drugs for treatment of diabetes.

USC SmartState Endowed Dr. Souvik Sen of the Stroke Center of Economic Excellence confers with Clinical Research Coordinator Hannah Kowalski, MPH, regarding a patient's test results. Dr. Sen was responsible for establishing the first Joint Commission Primary Stroke Center in the South Carolina Midlands. Now nearly three-quarters of the state's population lives within a 60-minute drive of a nationally certified stroke center.

Stroke

Date: 2007 **State Award Amount:** $5 million **Institutions:** MUSC/USC
Extramural Research Above Matching Requirement: $16.3 million
Endowed Chair in Stroke: Dr. Robert Adams (MUSC)
Countess Alicia Paolozzi Chair in Translational Neurology:
Dr. Marc Chimowitz (MUSC)
Endowed Chair in Clinical Neurology: Dr. Souvik Sen (USC)

The reduction in incidence of stroke and the provision of acute stroke care are goals of this Center. This collaborative effort enhances the research programs of MUSC, USC, Greenville Health Systems and the Greenwood Genetics Center and strengthens clinical and basic stroke research in South Carolina. With three SmartState Endowed Chair positions, this Center has increased translational stroke research and stimulates the development of new therapeutics, drug discovery and biotechnology. In May 2008, SmartState Chair Dr. Adams of MUSC implemented the REACH MUSC Network, which has provided around-the-clock, Internet-based stroke consultation for more than 2,000 patients. The REACH MUSC network is comprised of 15 sites; within the past six years, the percentage of South Carolinians within a 60 minute drive of an expert stroke center has increased from 38% to 76%. In 2011, SmartState Chair Dr. Sen of USC obtained the Midlands only Joint Commission certification, which is considered the gold standard in stroke care providers. In 2011, SmartState Chair Dr. Chimowitz published a landmark study in the *New England Journal of Medicine*, which is revolutionizing the way care is provide for post-stroke victims

Neuroscience

Award Date: 2003 **State Award Amount:** $3 million **Institution:** MUSC **Extramural Research:** $16.8 million
William H. Murray Endowed Chair in Neuropathology: Dr. Gary Aston-Jones
[MUSC will appoint Dr. Bruce Ovbiagele as the SMARTSTATE ENDOWED CHAIR IN MOVEMENT DISORDERS in Winter 2012.]
[MUSC is recruiting THE JOSEPHINE TUCKER MORSE ENDOWED CHAIR IN PARKINSON'S DISEASE RESEARCH.]

This Center researches age-related neurodegenerative problems including dementia, Alzheimer's, Parkinson's and stroke. SemiAlloGen is a Center-related startup company which developes vaccines and therapeutic treatments for Alzheimer's disease and cancer. In FY 2012, SmartState Endowed Chair Dr. Aston-Jones initiated a new program in Parkinson's Disease, partnering in research with other scientists at MUSC as well as Washington University-St. Louis, the University of Pennsylvania, Rush University, and University of Kentucky. Together, this team applied for a $11 million Morris K. Udall Center of Excellence in Parkinson's Disease. The Center has begun discussions with Cephalon and GlaxoSmithKline to test antagonists as treatment of obesity and addiction.

Health Care

5 Centers
11 SmartState Chairs

Dr. Matthew McEvoy, an anesthesiologist at MUSC, conducts Maintenance of Certification for Anesthesiologist for the American Board of Anesthesiology as part of the SmartState Clinical Effectiveness & Patient Safety Center simulation center.

Clinical Effectiveness and Patient Safety

Award Date: 2006 **State Award Amount:** $5 million **Institutions:** MUSC/USC

Extramural Research Above Matching Requirement: $9.1 million

Lewis Blackman Endowed Chair for Patient Simulation and Research for Health Sciences South Carolina: Dr. John Schaefer (MUSC)

SmartState Endowed Chair in Biomedical Informatics: Dr. Jihad S. Obeid (MUSC)

College of Nursing SmartState Endowed Chair for Health Informatics Quality and Safety Evaluation: Dr. Rita Snyder (USC)

This Center improves clinical education and patient safety through simulation technology. The Center collaborates with ten education partners, known as Healthcare Simulation South Carolina, and is recognized as one of the only such statewide organizations in the nation. The Center has provided more than 80,000 student encounters involving 200-plus faculty statewide. This Center has developed 300 active courses, 162 scenarios, and over 100,000 training simulations. A startup company, SimTunes, was co-founded by SmartState Endowed Chair Dr. John Schaefer to commercialize simulation educational technology. The Laerdal Corporation opened SimStore© in 2011, now with over 600 individual scenarios and 84 scenario sets available for annual licensing. The Center has developed innovative simulation technology to model realistic birthing issues; the Modular Fetal Delivery System provides the first shoulder dystocia (common birth emergency) simulation. MUSC SmartState Endowed Chair Dr. Obeid has collaborated with the Health Care Quality Center to create a complex informatics framework that will enable clinical researchers to use existing medical data for discovery research; this Clinical Data Warehouse enables researchers to browse massive amounts of clinical data while protecting the privacy and confidentiality of patients.

Health Facilities Design & Testing

Award Date: 2007 **State Award Amount:** $2 million **Institutions:** Clemson/MUSC

Extramural Research Above Matching Requirement: $2.1 million

Clemson: Clemson will recruit the Endowed Chair in Architecture & Health Research.

MUSC: MUSC is recruiting the Endowed Chair in Human Factors Medical Research.

This Center researches how health facility design impacts health and healthcare delivery and creates architectural settings that better support the well-being of patients and staff. The finalized Patient Room 2020 concept depicts a realistic in-patient hospital that provides an optimally safe and sanitary environment for healing via a modular design that integrates advanced technology throughout the health care facility. The prototype presents a 32-foot structural bay constructed from Corian that offers ample space for patient care, a family respite area, staff work area, and necessary bathroom space. Technology "touch points" are woven into the overall design, which include Radio Frequency Identification mirrors for content delivery and communication with medical staff, bedside workstations, vital sign monitoring, wireless power transmissions, and robotic medication delivery. Faculty personnel analyzed the fourth cycle of design research this past spring and focused on usability testing of the patient "headwall" and "footwall" to accommodate family members. Rooms are being tested in four Upstate hospitals.

SeniorSMART™

Date: 2007 **State Award:** $5 million **Institutions:** USC/Clemson
Extramural Research: $16.3 million
SmartState Endowed Chair in Community and Social Support—SmartHOME® at USC: Dr. Sue Levkoff (USC)
USC Chair II: CHAIR FOR MEMORY AND BRAIN FUNCTION
Clemson Chair: DRIVING, MOBILITY & PHYSICAL FUNCTIONING.

This Center focuses on research to foster independence for seniors via: SMARTBrain™ (maintaining intellectual activity); SMARTWheels™ (promoting independent mobility outside the home); and SMARTHome™ (maintaining independent mobility inside the home). In 2012, the Center, along with CU-ICAR, developed a driving simulator for clinical rehabilitation. The DriveSafety CDS-250 is housed at 21 clinic and research facilities and is used to rehabilitate aging drivers as well as veterans with physical and psychological wounds. Also in 2012, SmartState Endowed Chair Dr. Sue Levkoff created a startup company, Environment and Health Group, Inc., to develop health information technologies including Web 2.0, social media, and mobile applications to promote health and wellness and to improve chronic disease management among disadvantaged populations. Two company projects include the development of a low-cost, computer-based remote monitoring application for congestive heart disease and the creation of a computer application to aid Hispanic women struggling with obesity and diabetes.

(l to r) Dr. Deb Krotish, SmartState Endowed Chair Dr. Sue Levkof, and Dr. Juan Caicedo of the SeniorSMART™ Center of Economic Excellence test a grid which was designed in the engineering laboratory to detect falling objects. The test identifies objects as they hit the grid based on vibrations detected by sensors. The grid correctly identifies the object and the location of the fallen object, then transmits the data to a computer display. This grid was originally designed to help structural degradation of bridges. SeniorSMART™ researchers are using the technology to detect vibrations following the fall of individuals in homes, retirement communities, and health care facilities.

Medication Safety and Efficacy

Date: 2008 **State Award:** $2 million **Institutions:** MUSC/USC
Extramural Research Above Matching Requirement: $3.2 million
SmartState Chair in Medication Safety & Efficacy: Dr. Charles Bennett

This Center focuses on increasing drug safety and effectiveness, as well as decreasing medication errors by identifying the incidence and significance of adverse drug events. This data will be provided to hospitals, pharmaceutical and insurance companies, and governmental agencies for use in epidemiological and economic studies and will help lead to fewer drug injuries and improved drug effectiveness. In September 2011, Dr. Bennett joined colleagues for a panel discussion symposium entitled "Pros and Cons of the Prostate Specific Antigen Screening Test." The discussion garnered national news as scientists and doctors discussed the decision by the U.S. Preventive Services Task Force (USPSTF) to recommend against PSA-based screening. The symposium discussion marked the beginning of a state dialogue between community and physicians about the most appropriate strategy regarding prostate screenings.

HEALTH CARE CONT'D.

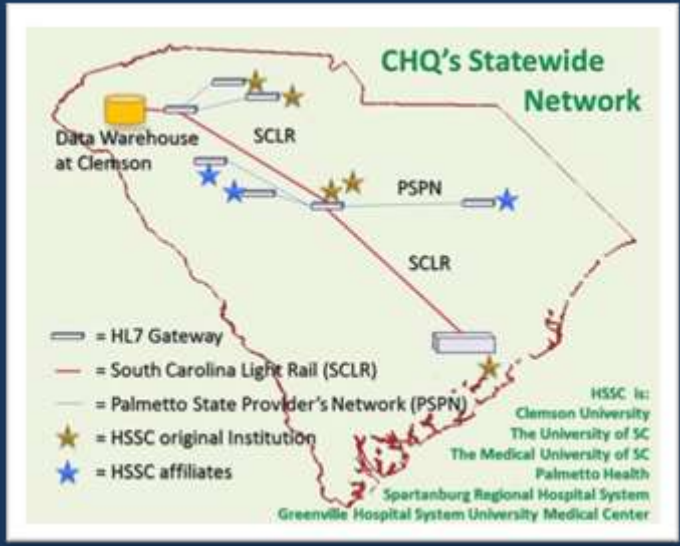
Health Care Quality

Award Date: 2007 **State Award Amount:** $5 million
Institutions: USC/MUSC/Clemson
Extramural Research Above Matching Requirement: $15.8M
James B. Duke SmartState Endowed Chair for Healthcare Quality: Jay Moskowitz (USC)
Chair in Medical Bioinformatics: Iain Sanderson (MUSC)

This Center conducts research on the state's major health problems, with the goal of improving health and the economy. The Center has partnered with the S.C. Hospital Association for multiple benefits, including supporting statewide initiatives and translating new products and processes. In 2009, the S.C. Healthcare Quality Trust was launched as a partnership between this Center, Health Sciences South Carolina, the S.C. Hospital Association, and Premier, Inc., with the goal of reducing healthcare-associated infections. According to Premier, Inc., infection reduction could save state hospitals up to $40 million per year. The Center, in coordination with MUSC's Office of Biomedical Informatics Services (OBIS), has customized many applications for use today by researchers across the state.

The Center is completing a study on hospital perioperative services, analyzing the use of engineering management tools to improve decision-making among perioperative staff. Researchers engaged small groups of staff to choose one of eight delay points as the most disruptive to efficient patient flow, then provided the group a simulation without two of the delay points so that the staff could understand how tools could be used to make the process more efficient. In FY 2012, the Center continued to encourage clinicians to transition to electronic health records. Also in FY 2012, researchers at the Center began the Care Transition Collaborative Initiative with partners BlueCross BlueShield of South Carolina and the S.C. Hospital Association; this initiative aims to reduce the number of preventable hospital readmissions.

Dr. Jay Moskowitz, James B. Duke Endowed Chair for Healthcare Quality at USC, and President and CEO of Health Sciences South Carolina.



A schematic of the Center for Health Care Quality's Data Warehouse Initiative, depicting the infrastructure map detailing how electronic research data is exchanged between the state's major hospital systems.

HEALTH SCIENCES SOUTH CAROLINA

In 2004, as the result of the academic research collaboration engendered by the Smart-State Program, the presidents of South Carolina's senior research institutions (Clemson, USC and MUSC), along with the heads of the state's three largest hospital systems (Palmetto Health, Greenville Hospital System, and Spartanburg Regional Medical Center), started a unique organization called Health Sciences South Carolina (HSSC). HSSC's primary mission as the nation's only statewide hospital biomedical research collaboration is to transform South Carolina's public health and economic being through health care research.

HSSC has become a national leader in statewide biomedical and health care research and is led by one of the USC SmartState Endowed Chairs, Dr. Jay Moskowitz, the James B. Duke SmartState Endowed Chair for Healthcare Quality. [See opposite page.] In 2006, The Duke Endowment awarded HSSC a $21 million grant, the largest health care initiative grant in the organization's history. Since 2006, The Duke Endowment has provided HSSC with additional grants exceeding $11 million. With these grants and other federal and private funding, HSSC has invested heavily in the SmartState Program, providing11 SmartState Centers $18 million in non-state matching funds.

One of HSSC's major health care initiatives is the Clinical Data Warehouse, which will assure high quality clinical care and facilitate clinical research. To further enhance the support of clinical research, another major initiative connects the management of electronic clinical research permissions with the Data Warehouse. This mechanism increases participation in clinical research by better informing participants; increases interest in clinical trials participation; and retains participants' preferences in a readily accessible form. Such research permissions and informed consents are typically collected on paper at the time of patient registration. HSSC assembled a team of state researchers to develop a novel method of presenting information and to capture the participants' preferences electronically. The project involved substantial analysis focused on key areas including review of business practices, registration processes, and permission collection workflows.

The team also worked with participants to develop best practices for presenting consent information to users via tablet technology and capturing permissions data. The result, funded by the National Library of Medicine and National Institutes of Health, is an open source software product which can be adopted for use nationally. An initial software version has been piloted at one institution in South Carolina and was well received by staff and patients. The software has also been adopted by another institution for use in its clinical research program.

HEALTH SCIENCES SOUTH CAROLINA

A Collaborative To Advance Health Sciences

Health Sciences South Carolina has made substantial non-state match investments in 11 SmartState Centers of Economic Excellence:

- Cancer Stem Cell Biology
- Childhood Neurotherapeutics
- Clinical Effectiveness and Patient Safety
- Health Care Quality
- Health Facilities Design and Testing
- Healthful Lifestyles
- Medication Safety & Efficacy
- Molecular Proteomics in Cardiovascular Disease Prevention and Treatment
- Regenerative Medicine
- SeniorSMART™
- Stroke

(To learn more about HSSC, visit: www.healthsciencessc.org .)

BIOTECHNOLOGY

10 CENTERS
21 SMARTSTATE CHAIRS

SmartState Endowed Chair Dr. Richard Swaja of the Regenerative Medicine Center (right) presents a plaque to former SmartState Review Board Chair Samuel Tenenbaum at the SmartState Program National Conference. Dr. Swaja was the Conference co-director.

Marine Genomics

Award Date: 2003 **State Award:** $4 million **Institutions:** MUSC/USC/Coll. of Charleston
Extramural Research Above Matching Requirement: $8.6 million
SmartState Endowed Chair in Marine Genomics: Dr. Louis J. Guillette (MUSC)
SmartState Endowed Chair in Bioinformatics: Dr. Gavin Naylor (MUSC)
SmartState Endowed Chair in Marine Genomics: Dr. Stephen Kresovich (USC)

This Center monitors and predicts the impact of environmental changes on marine biosystems. Collaborators include the Hollings Marine Laboratory, NOAA, the SC DNR, College of Charleston and NIST. The Center has partnered with two private companies to test the antiviral effect of algae incorporated in shrimp diets. Chair Dr. Kresovich is an expert in high-throughput whole genome sequencing and genotyping techniques studying human disease susceptibility and for mapping variability in genomes and populations. Chair Dr. Guillette studies environmental causation in wildlife for human diseases including premature ovarian failure and polycystic ovary disease, while Chair Dr. Naylor's research on shark and ray species has been featured in the *Bulletin of the American Museum of Natural History and Nature*.

Regenerative Medicine

Award Date: 2004 **State Award Amount:** $5 million **Institutions:** MUSC/USC/Clemson
Extramural Research Above Matching Requirement: $52.3 million
SmartState Endowed Chair in Regenerative Medicine: Dr. Richard Swaja (MUSC)
BlueCross BlueShield of SC Foundation Chair in CV Health: Dr. Martin Morad (USC)
Hansjörg Wyss Endowed Chair in Regenerative Medicine: Dr. Xuejun Wen (Clemson)

This Center researches the regeneration of tissue and organs for repairing, replacing, and maintaining organ function. This Center combines statewide expertise in developmental biology, adult stem cell technology, and tissue engineering. The Center has coordinated significant advances in multiple areas of bioengineering, wound healing, vascular biology, orthopedic materials science, and cardiac development as part of a broad effort to construct a biofabricated blood vessel network. This Center plays a major role in the $20M statewide NSF grant awarded in July 2009 for tissue/organ biofabrication. Two research contracts have been developed with Synthes USA. In 2011, SmartState Chair Dr. Morad hosted an international symposium on the role of adult stem cells in cardiovascular therapy; Dr. Morad continued his development of a biogenic pacemaker by attempting to introduce pacemaker genes using transposan technology to give the pace making property longevity for human use.

Molecular Proteomics in Cardiovascular Disease and Prevention

Award Date: 2006 **State Award Amount:** $5 million **Institution:** MUSC
Extramural Research Above Matching Requirement: $3.3 million
Chairs: MUSC is actively recruiting two SmartState Endowed Chairs for this Center.

This Center has identified a new biomarker class, micro-RNAs, that will have diagnostic, prognostic, and therapeutic importance for cardiac disease. The Center continues a statewide network of five care locations linked by a central bioinformatics core; this core allows patients who suffer or are at risk for CV disease to be screened. Nearly 450 patients have enrolled in the program; 16 biomarkers have been used to develop a unique biomarker portfolio to diagnose and predict left ventricular hypertrophy and diastolic heart failure.

Proteomics

Award Date: 2003 **State Award Amount:** $4 million **Institution:** MUSC
Extramural Research Above Matching Requirement: $20.6 million
SmartState Proteomics Chair: Dr. Richard Drake (MUSC)
[MUSC is actively recruiting a second SMARTSTATE ENDOWED CHAIR for this Center.]

This Center develops and uses high-end analytical technologies to understand the biologic profile of protein expression in health and disease. The field of proteomics leads to an understanding of cellular function at the molecular level and how this function adapts to disease. Grants for this Center included NIH funding for one of only ten U.S. National Heart, Lung and Blood Institute Proteomics Centers. SmartState Endowed Chair Dr. Drake and other researchers published an abstract in the *Journal of Proteome Research* which will provide a reference for future investigations for prostatic-disease biomarker studies.

Renal Disease Biomarkers

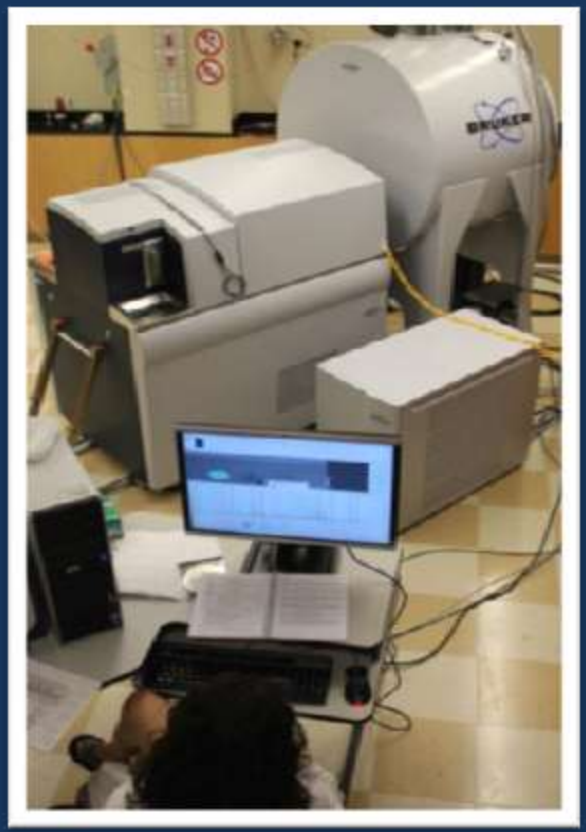
Award Date: 2008 **State Award Amount:** $5 million **Institution:** MUSC
Extramural Research Above Matching Requirement: $7.5 million
Chairs: MUSC is recruiting a CHAIR IN RENAL BIOMARKERS
and a CHAIR IN TRANSLATIONAL NEPHROLOGY RESEARCH.

This Center addresses the need for reliable and prognostic biomarkers and biological indicators for acute kidney injury and chronic renal (kidney) failure. Accurate and sensitive biomarkers are essential for early disease detection and treatment. This area of research is especially relevant in South Carolina; diabetes is the leading cause of kidney failure, and South Carolina has a higher rate of diabetes than the national average. In FY 2012, Center faculty created the SouthEastern Kidney Disease Consortium (SEKDC). Investigators have published a manuscript which identifies a set of proteins in urine that can distinguish between two common acute kidney diseases, which are difficult to diagnose clinically; this discovery may lead to developing a crucial clinical test. This Center has acquired specialized equipment to accelerate biomarker identification. Center research has led to startup company, Protara, LLC, which commercializes biomarker technologies. [See essay by Center investor Dialysis Clinics, Inc. on page 5.]

Rehabilitation and Reconstruction Sciences

Award Date: 2007 **State Award Amount:** $5 million **Institution:** USC
Extramural Research Above Matching Requirement: $17.0 million
Chair: USC will recruit a SMARTSTATE CHAIR IN RECONSTRUCTIVE METHODOLOGIES AND MATERIALS.

The Center is focused on medical and public health needs in the area of orthopedic disorders, exercise and sports-related injury prevention, treatment and rehabilitation. Collaboration among the four intellectual cores, Cellular Engineering; Rehabilitation and Performance Sciences; Epidemiology and Clinical Translation; and Education, translate basic science to bed-side care. The Center investigates the biologics of tissue-engineered materials and implantable devices to find solutions to musculoskeletal maladies. The Biologics & Spine division of global medical company Smith & Nephew invested a $5M match.



A technician uses the Solarix 70 Fourier Transform Mass Spectrometer, which was installed in FY 2012 at the MUSC Proteomics Center of Economic Excellence. This equipment is used for the analysis of proteins, peptides, lipids, and small drug metabolites directly from tissue specimens. In FY 2012, the Center also appointed its first SmartState Endowed Chair, Dr. Richard Drake.

BIOTECHNOLOGY CONT'D.

Advanced Tissue Biofabrication

Award Date: 2008 **State Award Amount:** $5 million **Institutions:** MUSC/USC/Clemson

MUSC Chair: MUSC is recruiting an ENDOWED CHAIR IN BIOFABRICATION BIOLOGY.

USC Chair: USC is recruiting an ENDOWED CHAIR IN BIOFABRICATION ENGINEERING.

Clemson: Clemson will recruit an ENDOWED CHAIR IN BIOFABRICATION ENGINEERING.

The vision for this Center involves industrial production of complex tissues and organs for the repair, replacement, and restoration of diseased cells, tissues, and organs. Researchers focus on "bioprinting," assembling human tissues and organs by layering living cells and a hydrogel. Tissue engineering can be a diagnostic tool: tissue grown in vitro can be used to test drug metabolism, uptake , toxicity, and pathogenicity. This Center plays a major role in the statewide $20 million NSF grant; the project's mission is to build tissue and organs from the inside-out, a unique approach.

Technology Center to Advance Healthful Lifestyles

Award Date: June 2009 **State Award Amount:** $3 million Institutions: USC/MUSC

Extramural Research Above Matching Requirement: $20.0 million

Endowed Chair in Technology Applications to Prevent and Manage Disease and Reduce Risk at MUSC: Frank Treiber

USC Chair: USC is recruiting a SMARTSTATE ENDOWED CHAIR IN TECHNOLOGY APPLICATION FOR HEALTH BEHAVIORS CHANGE.

This Center focuses on health problems caused by physical inactivity, poor diets, and other poor health behaviors to develop and test lifestyle interventions for improving health, preventing illness, and managing chronic health problems. Successful components will be translated into cost-effective programs and new products that will be marketed in clinical care, public health, worksites, and other community settings. SmartState Chair Dr. Frank Treiber has developed software that uses a video camera as a photoplethysmograph through a smartphone platform to monitor heart rate and provide biofeedback as part of a breathing meditation stress reduction program that manages hypertension. Other research revolves around the development of a Bluetooth-enabled carbon monoxide breath analyzer for use in smoking cessation intervention, as well as the development of a Bluetooth-enabled standard pill bottle cap holder which in combination with a software application can be used to assist patients in remembering to take their medications.

Inflammation & Fibrosis Research

Award Date: 2010 **State Award Amount:** $5 million **Institution:** MUSC

Extramural Research Above Matching Requirement: $7.7 million

Chairs: MUSC was awarded a SMARTSTATE CHAIR IN INFLAMMATION RESEARCH and a KITTY TRASK HOLT SMARTSTATE CHAIR FOR SCLERODERMA RESEARCH.

The Center and its two Chairs will address the need for novel anti-inflammatory and anti-fibrotic drug therapies by supporting a program that aligns clinical and basic science investigators with the common goal of developing effective treatment for inflammatory and fibrosing diseases. Inflammation and fibrosis are fundamental aspects of disease exemplified by two connective tissue diseases (CTD), lupus and scleroderma, each having pathobiologic pathways relevant to other diseases. MUSC investigators played a role in the approval of Benlysta, the first new drug to be FDA-approved for the treatment of lupus in more than 40 years. Dr.Hoffman founded a startup company, FibroTherapeutics, Inc. to develop treatments for fibrotic/inflammatory interstitial lung disease for which no FDA-approved treatments are currently available. The primary focus of the company is disease treatment based on the use of a peptide from the master regulatory protein caveolin-1.

CANCER

7 CENTERS
17 SMARTSTATE CHAIRS

Researcher Dr. Chang-uk Lim of the Translational Cancer Therapeutics Center examines cells in culture under a microscope.

Translational Cancer Therapeutics

Award Date: 2004 **State Award:** $5 million **Institutions:** MUSC/USC
Extramural Research Above Matching Requirement: $13.3 million
John C. West Chair in Cancer Research: Dr. Kenneth Tew (MUSC)
Endowed Chair in Translational Cancer Therapeutics: Dr. Igor Roninson (USC)

SmartState Endowed Chair Dr. Tew has an international reputation as a cancer drug researcher and developer. His research was pivotal in the design of treatment for hormone refractory prostate cancer. Dr. Tew's research has also proven instrumental in the late-stage clinical testing of two promising drugs for ovarian and lung cancer and another that serves as a modifier of bone marrow-mediated immune function. Dr. Tew was named Chairman Elect, Drug Discovery Development & Regulatory Affairs, American Society for Pharmacology and Experimental Therapeutics. A publication written in 2012 by Dr. Tew and other colleagues has led to the formulation of two clinical trials; one which will analyze biomarker expression in prostate cancer patients undergoing whole body irradiation treatments, while the other will study the response of cheek cells to exposure to hydrogen peroxide containing mouthwashes. [See page 31 for a profile of SmartState Endowed Chair Dr. Igor Roninson.]

Cancer Drug Discovery

Award Date: 2005 **State Award:** $5 million **Institutions:** MUSC/USC
Extramural Research Above Matching Requirement: $19.9 million
Charles & Carol Cooper Chair in Pharmacy: Dr. Charles Smith (MUSC)
GlaxoSmithKline Distinguished Endowed Chair: Dr. John Lemasters (MUSC)
Endowed Chair in Medicinal Chemistry: Dr. Patrick Woster (MUSC)
Additional Chairs: MUSC is recruiting a CHAIR IN STRUCTURAL BIOLOGY.

This Center provides mechanisms for target identification and generation of lead compounds in the drug discovery process, creating a productive interface between academics and biotechnology/ pharmaceutical industries. This Center also utilizes research approaches in structural biology for designing drug candidates and compound screening strategies. Using a drug screening core with chemical libraries of 50,000 compounds, Chair Dr. Charles Smith and another colleague identified compounds which inhibit PIM kinase enzymes which are over-expressed in cancer; this led to the formation of a startup company, Vortex Biotechnology Corporation. Chair Dr. Lemasters has identified a potential new therapy for the treatment of hemorrhagic injury, for which he has received Department of Defense funding. Chair Dr. Woster began two collaborations with fellow SmartState Chair Dr. Roninson; one project is a lead optimization study to identify therapeutically relevant kinase inhibitors, while the second project will design a scale-up synthesis for a potential antitumor compound for pre-clinical trials. Four startup companies are related to this Center.

Cancer cont'd.

Gastrointestinal Cancer Diagnostics

Award Date: 2005 **State Award Amount:** $5 million **Institution:** MUSC
Extramural Research Above Matching Requirement: $17.5 million
Grace E. DeWolff Chair in Medical Oncology: Dr. Melanie B. Thomas
[MUSC has appointed Dr. Carolyn Britten in July 2012 as the SmartState Endowed Chair in GI Malignancy Diagnostic & Therapeutic Trials.]

This Center researches translational medicine for gastrointestinal (GI) cancer patients in order to decrease cancer mortality and morbidity. Areas of research include molecular profiling, therapeutic targets, screening technologies, therapy, and population studies, with particular emphasis on esophageal cancer, which is prevalent in South Carolina. Investment partners for this Center include Roche Carolina and Bank of America. Through the leadership of SmartState Endowed Chair Dr. Melanie Thomas, also Associate Director of Clinical Investigations at the Hollings Cancer Center, this Center has initiated numerous clinical trials of novel biologic anti-cancer agents for patients with malignancies in all sites in the GI tract. The Center initiated a new biomarker research project led by Dr. Thomas and fellow SmartState Chair Dr. Charles Smith. The Center started eight new therapeutic trials in the last year.

Tobacco-Related Malignancies

Award Date: 2007 **State Award Amount:** $5 million **Institution:** MUSC
Extramural Research Above Matching Requirement: $45.1 million
Chairs: MUSC is recruiting the BMW Endowed Chair in Cancer Research
and The Burtschy Family Distinguished SmartState Endowed Chair in Lung Cancer Research

This Center is devoted to discovering tobacco-related malignancy biomarkers. Hollings Cancer Center (HCC) has used revenue from a statewide cigarette tax to expand the availability of clinical trials. The Center has more than $22 million in cancer research funding and has 30 active clinical trials, many multidisciplinary in nature, with many institutions around the state and country. As a result of the HCC National Cancer Institute designation, a collaborative project, NAVIGATE, has been initiated between HCC, Spartanburg Regional Healthcare System, and St. Joseph's/Candler Hospital of Savannah to elucidate specific barriers experienced by thoracic and esophageal cancer patients when seeking timely treatment options. New Center researcher Dr. Michael Cummings will begin work on establishing comprehensive smoking-cessation services including CT-scan screening for lung cancer in heavy smokers and former heavy smokers in the state.

Cancer Disparities

Award Date: 2008 **State Award Amount:** $3.6 million **Institutions:** MUSC/USC/South Carolina State University
Extramural Research Above Matching Requirement: $22.6 million
SmartState AT&T Distinguished Endowed Chair in Cancer Equity: Dr. Chanita Hughes-Halbert
MUSC Chairs: MUSC is actively recruiting two SmartState Endowed Chairs in Cancer Disparities.
USC Chair: USC is actively recruiting a SmartState Endowed Chair in Cancer Disparities.

This Center will increase prostate cancer screening and early detection among African-American men. Despite the fact that prostate cancer mortality rates in South Carolina are three times greater for African-Americans than for Caucasians, African-Americans are significantly underrepresented in prostate cancer clinical trials. The Center will conduct prostate cancer clinical trials and examine aspects of obesity and lifestyle modifications as contributing factors to prostate cancer; the Center will also examine factors that influence the screening and treatment of African-American men. The AT&T Foundation provided a $1 million gift to MUSC to provide free prostate cancer screenings and treatment advice and education to African-Americans in South Carolina. The Center has conducted over ten cancer education programs in African-American communities. Through such seminars, faculty have been able to determine a statistically significant shift toward more positive perceptions of cancer clinical trials. [See profile of Dr. Hughes-Halbert on page 21.]

Cancer Stem Cell Biology & Therapy

Extramural Research Above Matching Requirement: $15.4 million

Award Date: 2008 **State Award Amount:** $5 million **Institutions:** MUSC/Clemson

The Abney Chair Remembering Sally Abney Rose: Dr. Zihai Li

Chairs: MUSC is recruiting a SMARTSTATE ENDOWED CHAIR IN BIOMEDICAL ENGINEERING.

This Center focuses on developing new technologies for isolating, growing and manipulating cancer stem cells. Cancer stem cells are adult stem cells that have the ability to reproduce themselves and develop into cancer cells. The Center will find ways to use adult stem cells from bone marrow or organs to treat cancer. The work of this Center generates further understanding of cancer stem cells and ways to eradicate them without harming healthy cells. Research could also lead to the engineering of healthy adult stem cells that can replace cancerous cells in the body.

This Center will seek to contribute a repository of adult cancer stem cells to the Health Sciences South Carolina tissue repository for use in further research across South Carolina. Center senior researcher Dr. Bryan Toole is studying the use of hyaluronan, a compound which resides on the surface of cancer stem-like cells, as a treatment for glioblastoma tumors. Hyaluronan, along with two other substances, regulate the activities of cancer stem-like cells. In FY 2012, Dr. Toole received new grant funding from the U.S. Department of Defense to demonstrate that hyaluronan has immediate potential for use in conjunction with existing agents for treatment of drug-resistant, recurrent, and metastatic forms of ovarian carcinomas.

SmartState Endowed Chair Dr. Zihai Li of the Cancer Stem Cell Biology & Therapy Center of Economic Excellence.

Lipidomics, Pathobiology & Therapy

Extramural Research Above Matching Requirement: $23.4 million

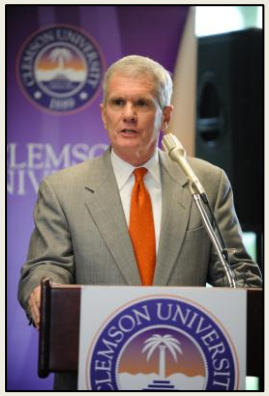
Award Date: 2009 **State Award:** $5 million **Institution:** MUSC

Chairs: MUSC is recruiting a SMARTSTATE ENDOWED CHAIR IN LIPIDOMICS AND PATHOBIOLOGY and a SMARTSTATE ENDOWED CHAIR IN LIPIDOMICS DRUG DISCOVERY.

This Center will translate basic lipidomics research into an understanding of how lipids play a role in health problems such as cancer, inflammation, and diabetes. Researchers will identify new targets for diagnostics or treatments. The American Society for Biochemistry and Molecular Biology named Center senior researcher Dr. Yusuf Hannun the winner of the 2010 Avanti Award in Lipids. The award recognizes Hannun's work on bioactive sphingolipids, a class of lipids that have emerged as critical regulators of a multitude of cell functions and, when defective, can cause disorders with significant medical effects. In 2011, the Center organized the Sixth International Charleston Ceramide Conference in Switzerland. The Conference featured over 130 international attendees. The Center has established an Animal Pathobiology Core for the facilitation of preclinical studies which is focused on generating, acquiring, and using genetically-modified mice with emphasis on enzymes of sphingolipid metabolism, targets of bioactive lipids, and genetically-interacting components. With aid from SmartState Endowed Chair Dr. Jihad Obeid, Center researchers have launched a Lipidomics Research Portal, a novel approach to provide researchers with an online tool to request lipidomics core services, share experimental data, network with peers, and publicize discoveries in the field.

SmartState Review Board

The SmartState Review Board consists of eleven appointed members: three appointed by the Governor, three by the President Pro Tempore of the State Senate, three by the Speaker of the State House of Representatives, one by the chairman of the Senate Finance Committee, and one by the chairman of the House Ways and Means Committee. Members are appointed to serve three-year terms. The purpose of the SmartState Review Board is to oversee the operation of the SmartState Program. [Members depicted below indicate service during FY 2012. Review Board member Catherine Heigel resigned in July 2012.]



MUSC President Greenberg (top), and USC President Pastides (bottom) at the SmartState Program National Conference. The presidents of Clemson, MUSC, and USC serve as ex-officio, non-voting members of the SmartState Review Board. Clemson University President Barker is shown at the upper left side of the page.

Top: **Regan Voit** (Chair) [SEN. FIN. CHAIR], **Melvin Williams** (Vice Chair) [SEN. PRO TEMP.], **Keith Munson** (Secretary) [GOVERNOR].
Middle: **Bobby Pearce** [SPEAKER OF THE HOUSE], **Patricia Wilson** [SPEAKER OF THE HOUSE], **J. Lyles Glenn** [GOVERNOR].
Bottom: **Michael Couick** [SEN. PRO TEMP.], **Lisa Main** [SPEAKER OF THE HOUSE], **Catherine Heigel** [CHR. HOUSE W&M], **Patrick Turner** [SEN. PRO TEMP.].

South Carolina Centers of Economic Excellence Council of Chairs

First Row: Robert Adams, Gary Aston-Jones, Brian Benicewicz, Charles Bennett, Dan Gabriel Cacuci, Marc Chimowitz, Richard Drake, Zoran Filipi, Todd Hubing.

Second Row: Louis Guillette, Mark Helpern, Simon Hudson (FY 2012 Council Chair), Chanita Hughes-Halbert, Eric Johnson, Steve Kresovich, Jochen Lauterbach, John Lemasters, Sue Levkoff, Zihai Li, Scott Mason.

Third Row: Martin Morad, Jay Moskowitz, Gavin Naylor, Jihad Obeid, John Regalbuto, Kenneth Reifsnider, Igor Roninson, Chris Rorden, Iain Sanderson, John Schaefer, Souvik Sen.

Fourth Row: Charles Smith, Rita Snyder, Richard Swaja, Kenneth Tew, Melanie Thomas, Frank Treiber, Paul Venhovens, Richard Webb, Xuejun Wen, Patrick Woster.

For additional program information, contact S.C. Commission on Higher Education staff:

Mr. Arik Bjorn
Program Manager
Academic Affairs & Licensing
803.737.2293
abjorn@che.sc.gov

Dr. Argentini Anderson
Program Manager
Academic Affairs and Licensing
803.737.2276
aanderson@che.sc.gov

Ms. Laura Belcher
Program Coordinator
Academic Affairs and Licensing
803.737.4854
lbelcher@che.sc.gov

SmartState Program Website:
WWW.SMARTSTATESC.ORG

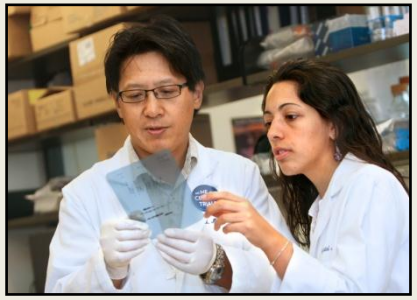
SmartState Program
South Carolina Commission on Higher Education
1122 Lady Street Suite 300 Columbia, SC 29201

For university-specific inquiries, please contact:

CLEMSON UNIVERSITY
Ms. Cathy Sams
Chief Public Affairs Officer
& Assistant to the President
864.656.4233
ctsams@clemson.edu

MEDICAL UNIVERSITY OF SOUTH CAROLINA
Ms. Sarah King
Director, Office of Public Relations
843.792.3621
kingsara@musc.edu

UNIVERSITY OF SOUTH CAROLINA
Mr. Wes Hickman
Director, News & Internal Comm.
803.777.3478
whickman@mailbox.sc.edu



SmartState Program Mission Statement

The South Carolina SmartState™ Program serves the public interest by creating incentives for the state's research universities, in cooperation with other institutions of higher education in the state, to raise capital from non-state sources to fund endowments for specialized research professorships. These professorships in turn serve as the nucleus for unique, university-based research centers which cultivate critical, public-private industrial partnerships, expand the state's knowledge base, create well-paying jobs, and enhance economic opportunities and improve the quality of life for the people of South Carolina.

The *SmartState Program Annual Report to the South Carolina General Assembly and the South Carolina Budget & Control Board Report* is published annually by the SmartState Review Board and the South Carolina Commission on Higher Education in accordance with S.C. 2-75-10.

This is an electronic version of the 2011-2012 SmartState Program Annual Report. Hardcopies of the electronic version are produced and paid for by the user and/or the user's company, organization, governmental agency, etc.

SmartState™
SC Centers of Economic Excellence

PUBLICATION DATE: November 30, 2012

Rear Cover: With the exception of the three research institutions, the organizations represented are non-state investors of $500,000 or more for individual or multiple SmartState Centers of Economic Excellence. (Special thanks to Thomas L. Hamm II of MUSC for graphic design assistance.)

We believe in SmartState™

SC Centers of Economic Excellence

BMW

santee cooper®

PalmettoNet™
A Spirit Communications Company

OKUMA

MICHELIN
A better way forward

CLEMSON UNIVERSITY

MUSC
MEDICAL UNIVERSITY of SOUTH CAROLINA

UNIVERSITY OF SOUTH CAROLINA

THE DUKE ENDOWMENT

GREENVILLE HOSPITAL SYSTEM
UNIVERSITY MEDICAL CENTER

HEALTH SCIENCES SOUTH CAROLINA
A Collaborative To Advance Health Sciences

DCi

TOYOTA

FLUOR®

Westinghouse

KENTWOOL®

COMPORIUM®
Making Life Easier®